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Multi-tasking Assessment for Personnel Selection and Development

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14. ABSTRACT *(Maximum 200 words)*:

Multi-tasking (MT) is prevalent in many work environments. While there are often negative consequences of MT, such as increased error, stress, and turnover, some individuals thrive in MT environments. An assessment tool that predicts performance in different MT environments would be invaluable for personnel selection and assignment. A central purpose of the present research was to investigate variations that exist among MT environments in order to form a better understanding of the demands placed on workers in these different environments. From a review of MT-related literature, and interviews with experts from different Military Occupational Specialties (MOS), we distilled individual differences and environmental variables that affect performance in different MT environments. Based on this research, we created a model of MT environments that varies along three main dimensions: type of MT required (decision-making, information-monitoring, and task-flow management), intensity of MT, and consequences of failure. The model was then used to guide the development of a measurement approach which assesses both MT environments and individuals' ability to perform well in those environments. The purpose, scope, and framework of this comprehensive Multi-Tasking Assessment System are described in the report, as well as a description of additional research necessary for the development of the system.

15. SUBJECT TERMS

Multi-tasking, assessment, environmental demands, selection

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MULTI-TASKING ASSESSMENT FOR PERSONNEL SELECTION AND DEVELOPMENT

EXECUTIVE SUMMARY

Research Requirement:

The requirement to perform more than one task within a limited period of time is prevalent in work environments, and the number of jobs that require multi-tasking (MT) may be rising. Unfortunately, research has shown that MT has serious negative consequences to morale and performance. Yet, research has also shown that some individuals seem resistant to the negative effects of MT, and even seem to thrive on the challenge. If individuals vary in their ability to multi-task, it should be possible to develop a screening test that could be used for selection or placement purposes. A reliable and valid assessment instrument would be highly useful to many different civilian and military organizations. Training costs, turnover, and attrition could be reduced for many MT jobs by using the test to select those individuals who would perform well on the job.

However, the indubitable variation among MT environments calls into question the idea that a single measure of MT ability is sufficient to the task of predicting performance in a wide range of MT jobs. It is unlikely that any single measure of MT ability will equally predict performance in varying MT environments. Therefore, it may be necessary to create multiple measures of MT ability, each specific to the unique job demands placed on workers by different MT environments. To do so, a better understanding is needed of the variation among MT environments, and how that variation is related to job demands and individual abilities.

A central purpose of the present research was to investigate variation that exists among MT environments to form a better understanding of the job demands placed on workers in these environments. The primary technical objective of the present research was to design a measurement approach that could be used to predict performance in *different kinds* of MT environments – especially those likely to be encountered by first-term Army enlistees.

Procedure:

The research was initiated with an analysis of the psychological literature related to MT. The purpose of the review was to identify individual difference and environmental variables that research has shown affect performance in MT environments. The second task was to develop a model of real-world MT environments that defines them, distinguishes them from non-MT environments, explains their commonalities, and describes how they vary. To accomplish this task, a set of ten first-term Military Occupational Specialties (MOSs) was identified for study. The jobs were then analyzed by interviewing individuals who had extensive knowledge and experience with each MOS. The interview results were then used to develop an MT environment model. Key individual difference variables were matched to specific characteristics of MT environments identified in the interviews. This mapping was then compared to the assessment

capabilities of an existing measure of MT ability. Additional features were then identified that are absent from the existing measure, but could be incorporated into new versions. A measurement approach was then designed based on this analysis. The resulting measurement approach addresses both environmental and individual assessment needs. A plan was developed for constructing the measurement instruments, and conducting validity studies.

Findings:

Based on the literature review, a list was compiled of dimensions upon which MT environments likely vary. The compilation focused on the variables that other basic and applied researchers have investigated, that seem the most important characteristics of MT environments, and that seem the most relevant to potential individual differences.

The interview responses showed that the MOS's investigated vary on many dimensions. Three different dimensions were most salient in the data: the *type* of multitasking required, the *intensity* of the MT, and the *consequences* of failure. Patterns of variation also emerged from the data. Certain environmental characteristics seem to cluster together in MT jobs, such as high levels of autonomy in prioritizing tasks and the presentation of ill-specified problem spaces. Based on these findings, a model was developed of MT environments. The model proposes that the variance among MT environments is multidimensional. Some dimensions on which MT environments vary have the result of placing different demands on workers, while other dimensions do not. The model states that key dimensions cluster to form different types or kinds of environments. Therefore, it presents a typology of MT environments that captures many important differences, particularly differences that place different kinds of demands on workers. The typology includes three kinds of environments. The first kind requires high levels of decision-making capability. The second kind presents workers with well-defined problems that require routine decision-making. A third kind is characterized by its multiple sources of information. The three types of environments appeared to place differing emphasis on the ability to prioritize, make decisions, and manage time, among other key job demands.

The model was used to guide the design of a measurement approach, which could be used to evaluate multitasking ability in a wide variety of environments. The measurement approach is actually a relatively complex assessment system, the *Multi-Tasking Assessment System (MTAS).* The MTAS is designed to assess individuals' MT abilities, as well as work environments to determine (1) whether an environment qualifies as an MT work setting and (2) the kinds of MT demands it places on workers. The MTAS consists of two main components: the Environment Assessment Tool (ENVAT), which assesses the MT requirements of work environments, and a test component that includes three basic versions of a Multi-Tasking Ability Test (MTAT), each of which assesses individuals' performance in a particular type of MT environment. The testing component also includes three sub-versions of each MTAT test, which are adaptively administered and are designed to tap performance differences associated with environmental variation at three levels of intensity.

Utilization and Dissemination of Findings:

The model developed in the present research advances knowledge about how different environments place different demands on workers. It offers the opportunity to further advance our understanding of MT for scientific and pragmatic concerns. First, it offers basic researchers a testable model upon which to base continued study of MT abilities. Second, it offers applied researchers guidance in developing assessment instruments. It focuses research on MT on complex real-world environments, and away from the current emphasis on the simpler laboratory setting.

The MTAS is a flexible system that provides tailored assessments of particular MT environments as well as individual tests that tap the demands required by those environments. The flexibility of the proposed MTAS allows it to be used both as a selection tool and as a placement tool for prospective job candidates. Likewise, a job placement counselor might administer all three versions of the MTAT to a job seeker, then use information provided in the test manual to provide guidance about which workplace environments the job seeker would be best suited for.

MULTI-TASKING ASSESSMENT FOR PERSONNEL SELECTION AND DEVELOPMENT

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MULTI-TASKING ASSESSMENT FOR PERSONNEL SELECTION AND DEVELOPMENT

INTRODUCTION

The requirement to perform more than one task within a limited period of time is prevalent in work environments, and the number of jobs that require multi-tasking (MT) may be rising. In recent years, many military and civilian organizations have reduced staff in an effort to boost productivity and decrease costs. In most cases, task load was not concomitantly reduced. Hence, the effect of staff reductions has been to increase MT requirements. While it is possible that productivity was enhanced by these actions, MT has a significant downside. Research has shown that MT has serious negative consequences to morale and performance (Bogner, 1994; Cook & Woods, 1994; Proctor, Wang, and Pick, 1998; Wickens, 1980; Kahneman, 1973; Meyer & Kieras, 1997). Field studies have associated MT with increased error, burnout, stress, and attrition in work environments such as air traffic control (ATC), nursing, and emergency dispatching (Franklin & Hunt, 1993; Joslyn & Hunt, 1998). Moreover, the ostensible productivity benefits of MT may be illusory because overall performance is typically slowed under MT conditions (Meyer & Kieras, 1997).

Yet, research has also shown that some individuals seem resistant to the negative effects of MT, and even seem to thrive on the challenge. Laboratory studies have shown that some people do not show the typical performance decrement associated with multi-tasking conditions (Rubinstein, Meyer & Evans, 2001; Schumacher, Seymour, Glass, Fencsik, Lauber, Kieras, Meyer, 2001). Other studies have shown that individual differences in cognitive processing and personality are related to performance differences observed under MT conditions (e.g., Brookings, & Damos, 1991; Dickman, 1990; Dickman & Meyer, 1988; Ishizaka, Marshall, Conte, 2001). For example, some individuals seem to be better able to prioritize multiple tasks and switch mental set with each new task (e.g., Burgess, 2000; Fischer, Morrin, & Joslyn, 2003; Gopher, 1982; Sohn and Anderson, 2001; Wickens, 1999). Extraversion and Type-A behavior pattern (TABP) have also been shown to influence performance in laboratory MT conditions (Conte, Rizzuto, & Steiner, 1999; Lieberman and Rosenthal, 2001).

Although a variety of cognitive and personality individual difference variables have been shown to influence performance in MT, their relative importance probably depends on the particular environment being considered. It is likely that some variables, such as the ability to effectively prioritize, are much more critical to successful performance in some environments than in others. This is simply because MT environments undoubtedly vary in the kind of demands they make on workers' abilities. A better understanding of the relationships among individual variables and environmental variables is needed to fully understand why some people perform better than others in MT settings. In summary, it appears that individual differences in elemental cognitive abilities and personality play an important role in determining MT performance. However, a comprehensive model is needed of individual difference variation as it relates to environmental variation.

If individuals vary in their ability to multi-task, it should be possible to measure that ability and use the measurement to predict future performance in MT environments. In other words, it should be possible to develop a screening test of MT ability that could be used for selection or placement purposes. A reliable and valid assessment instrument would be highly useful. Many different civilian and military organizations could use it to identify individuals who are likely to perform well in MT jobs, and those that will probably perform poorly. Training costs, turnover, and attrition for many MT jobs could be reduced by using the test to select those individuals who would perform well on the job.

Indeed, several potential measures of MT ability have been developed (e.g., Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Comstock & Arnegard, 1992; Joslyn & Hunt, 1998; Proctor, Wang, and Pick, 1998; Shallice & Burgess, 1991; Yee, Hunt, & Pellegrino, 1991) and research is underway to develop a new test based on Joslyn's and Hunt's (1998) original work (Fischer, Morrin, & Joslyn, 2003). Some of these measures have been developed for neurologically disabled populations (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Shallice & Burgess, 1991), making them unsuitable for selection and placement purposes for use with normal populations. The predictive validity of several other instruments has not been evaluated or has failed to meet the criteria necessary for a selection or placement test (Comstock & Arnegard, 1992; Proctor, Wang, and Pick, 1998; Yee, Hunt, & Pellegrino, 1991).

The most promising existing instrument that purports to measure individual differences in MT ability is the Abstract Decision Making task (ADM), originally developed by Joslyn and Hunt (1998). It stands heads above other potential assessment instruments because it has been shown to predict performance in two very different MT work environments (dispatching and air traffic control) at unusually high levels of accuracy, accounting for nearly 50% of the variance in simulated dispatching performance and over 25% of the variance in simulated ATC. It is a computer-based task that can be simply and quickly administered with minimal training, and requires no domain knowledge. For these reasons, effort is underway to develop the ADM laboratory task as a predictive measure of MT ability.[1]

The new test that is based on ADM and is currently under development (Multi-Tasking Ability Test (MTAT); Fischer, Morrin, & Joslyn, 2003) is designed to measure the ability to perform cognitive tasks that are common to most MT environments. Cognitive task analysis (Fischer, Morrin, & Joslyn, 2003) of the MTAT suggests that it requires test takers to employ cognitive abilities that are demanded by many, if not all, MT environments. For example, the MTAT requires the test taker to employ his/her prospective memory. Individuals who do not effectively use their prospective memory do poorly on the MTAT, and also perform poorly in MT environments. Similarly, the MTAT places heavy demands on working memory, which is a cognitive resource individuals must utilize effectively to perform well in most MT environments.

Although research has shown that the ADM task predicts performance in two MT environments at unusually high accuracy levels, it also shows that the ADM task does a better job of predicting skill in emergency dispatching than in ATC (Joslyn & Hunt, 1998). Because the new MTAT is closely based on ADM, it is likely that the MTAT will also vary in its ability to predict performance in different MT environments. Differential predictive validity is expected because the environments themselves vary along numerous dimensions. Fischer, Morrin, & Joslyn (2003) argue that all MT environments share several characteristics that the MTAT also shares. However, substantial variation also exists among MT environments. Some dimensions on

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[1] See Fischer, Morrin, & Joslyn (2003) for a thorough discussion of existing measures of MT ability, and the relative advantages of the ADM task as a potential assessment instrument.

which MT environments vary are not simulated by the MTAT. Other variables are represented by the MTAT, but only one end of the dimension is simulated. For example, some jobs offer the opportunity to create novel and creative solutions to ill-defined problem spaces. In contrast, others present problem spaces for which only a single solution is appropriate. Effective decision making in environments that present well-defined problems depends on the ability to accurately assess the situation and match it to the single appropriate solution, not to create a novel solution. The problems offered by the MTAT do not require creative solutions; there is only one correct solution. It is, therefore, likely that the MTAT would be a better predictor of performance in environments that present well-defined problem spaces to the worker.

The indubitable variation among MT environments calls into question the idea that a single measure of MT ability is sufficient to the task of predicting performance in a wide range of MT jobs. It is unlikely that the MTAT will equally predict performance in MT environments that vary considerably in the types of job demands they place on workers. The new MTAT will probably be a less powerful predictor of performance for some MT environments than for others. Therefore, it may be necessary to create multiple measures of MT ability, perhaps multiple versions of the MTAT, each specific to the unique job demands placed on workers by different MT environments. An idealistic solution would be to create and tailor separate MT ability measures for each MT environment for which a predictor was desired. Yet, it is not practical to create a tailored MT ability measure for every MT job that exists. It seems a tradeoff must be made between practical realities and optimal predictive validity.

Perhaps the solution to the tension between practical concerns and the need for the most accurate predictors is a better understanding of the relationships among individual difference and environmental variables. It is possible that environments vary in typical and systematic ways, and that this systematic variation is related to individual difference variables. It might be possible to identify environmental *types*, which would be characterized by the values they took along key variables in a multi-dimensional space. In other words, there may be major differences among MT environments that can be dimensionalized so as to identify different *kinds* or *clusters* of MT jobs. It is further possible that these different kinds of jobs could be differentiated by the different demands they place on workers and, hence, the different kinds of individual capabilities they require. If environmental types could reliably be identified, and the variation among environments is related to individual difference abilities, then it would also be possible to develop measures of the abilities demanded by the environmental types. Fewer assessment instruments would be necessary to accurately predict MT performance if a useful typology of MT environments could be developed.

A central purpose of the present research was to investigate variation that exists among MT environments to form a better understanding of the job demands placed on workers in these environments. Researchers understand that MT environments vary greatly in superficial characteristics and in the background knowledge they require. What scientists do not yet understand is whether MT environments vary in ways that are related to variation in individuals' cognitive abilities or personality. A literature review was conducted to identify key individual difference variables and key environmental variables shown to affect performance in MT settings. To further investigate variation among MT environments, a series of interviews was conducted with subject matter experts (SME) in ten different military jobs. The ten environments were selected because they appeared to vary in the degree and kind of MT capabilities they demanded. Based on data gathered in the interviews, the results of the literature review, and our previous research, a comprehensive model was developed that explains the relationship between environmental variation among MT work settings to individual difference abilities. The model was then used to guide design of a measurement approach for assessing MT ability variation pertinent to different kinds of MT environments. The remainder of this report discusses the methods and findings of the present research.

OVERVIEW OF PHASE I RESEARCH

The primary technical objective of the present research was to develop a plan for the design of a set of reliable, valid, and practical measures of multi-tasking ability that could predict performance in *different kinds* of MT environments – especially those likely to be encountered by first-term Army enlistees. Supporting technical objectives were to (1) develop a model of MT environments that explains their commonalities and differences and (2) identify the individual difference variables that differentially influence performance in different MT environments. The utility of multiple measures, which the present research identified as needed, will be to select applicants that are most likely to succeed in a *variety* of MT jobs, thereby reducing training costs and attrition.

Figure 1 depicts the strategy employed in the present research. The research was initiated by first conducting an analysis of psychological literature related to MT in order to identify individual difference and environmental variables that research has shown contribute to performance in MT environments, whether in the laboratory or in the field. The primary product of Task 1 was a comprehensive and detailed set of cognitive and non-cognitive individual variables as well as environmental variables that are related to successful MT performance.

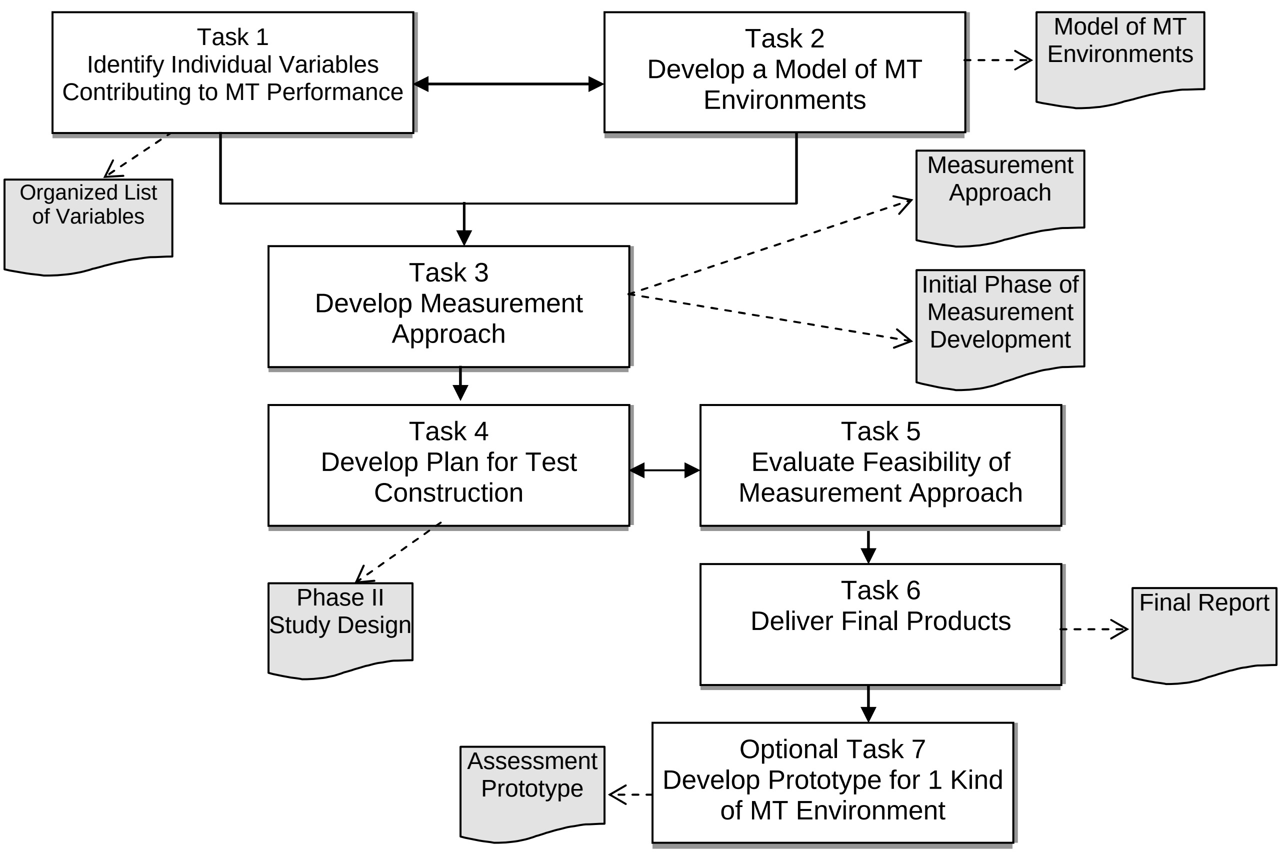


Figure 1. Project tasks and deliverables.

The second task was to develop a model of MT environments that explains how they vary and what they have in common. To accomplish this task, we first developed criteria to guide the selection of a set of first-term MOSs to study. To maximize our ability to distinguish environments that vary in degree or kind, we selected 10 first-term MOSs. We then analyzed the jobs by interviewing individuals who had extensive knowledge and experience with each MOS. The interview data was used to develop abstract profiles of different types of MT environments. The resulting model of MT environments delineates the factors that distinguish one MT environment from another, as well as identifies the variables that distinguish these jobs from non-MT environments.

Based on the products of Tasks 1 and 2, a measurement approach was designed (Task 3) by first matching key individual variables to specific characteristics of multi-tasking environments. This mapping was then compared to the assessment capabilities of the MTAT. Having identified individual variables that are, and are not, measured by the MTAT, additional features were then identified that may be incorporated into new versions of the MTAT. A measurement approach was then developed that addresses both environmental and individual assessment needs.

In Task 4 a plan was developed for constructing the measurement instruments, and conducting validity studies. The findings and products of the research effort are described in greater detail in the remainder of this report.

REVIEW OF LITERATURE

To identify individual difference factors related to performance in MT environments, an extensive review of the literature relevant to MT was conducted. A variety of sources was reviewed including published laboratory experiments, theoretical articles, and applied research. Literature from a variety of academic and government databases was queried, such as ERIC (educational literature), NTIC and DTIC (military and federal government literature), PsycINFO (psychological literature), and Infosurf and Elsevier Science Direct Electronic Journals Databases. The keywords used in the search included terms such as: MT, multi-tasking, multi-task, time sharing, dual tasks, task switching, time-pressured decision-making, and individual differences. Research on some of the key individual difference traits and cognitive factors that contribute to MT performance was also reviewed, such as information coordination, polychronicity, divided attention, selective attention, and prospective memory. Additional sources were identified from the reference sections of reviewed sources, as well as from Internet searches of leading researchers' websites.

Approximately 237 articles were selected for review. Many of the articles were only tangentially related to multi-tasking or did not appear to relate to multi-tasking as we defined it. For example, some articles examined performance on multiple sequential tasks rather than on multiple simultaneous tasks, which is integral to our definition of MT. The review also focused on articles that addressed individual differences in MT performance of non-clinical adult populations. In addition, previous review of MT literature had focused primarily on cognitive variables, so special emphasis was placed on reviewing sources relating personality traits to MT performance. A coding sheet was used to record relevant individual difference variables and how they were measured, as well as characteristics of the MT environment; and the interaction – if any – between the two.

Summary of Results

Many of the reviewed studies examined the correlation among individual differences measures and performance in real-world or laboratory MT environments. For example, Conte and Jacobs (2003) found correlations between supervisory ratings of job performance in MT environments and personality dimensions such as extraversion, conscientiousness, polychronicity, and neuroticism. Other studies looked at the relationship between personality traits and task performance in more controlled MT environments. Szymura and Necka (1998) and Lieberman and Rosenthal (2001), for example, demonstrated the relationship between extraversion and performance on MT laboratory tasks. In these studies, introverts and extroverts performed individual tasks equally well, but when required to perform the tasks nearly simultaneously (i.e., to multi-task), introverts' performance on the secondary task tended to decrease. Other correlational studies focused more on cognitive skills and abilities. In Chiles, Jennings, and West's study (1972), experimenters administered a battery of assessments to FAA trainees, then looked at which ones best correlated with supervisory ratings and later on-the-job performance ratings. They found that even simple, abstract assessment tasks were good predictors of future performance in real-world environments. More recently, Heil (1999) administered a battery of cognitive tests (such as fluid intelligence, working memory, and reasoning ability) to incumbent air traffic controllers and found that performance patterns indicated three main factors or clusters of tasks: dynamic tasks that require perceptual speed and fluid intelligence, reasoning tasks that require application of prior knowledge, and analytical and procedural accuracy tasks that require memory for following rules.

The findings of correlational studies, however, were not always consistent. For example, Jerneic and Sverko (1994) failed to find significant correlations between personality factors and MT task performance, though they did find correlations between cognitive abilities and task performance. Delbridge (2001) administered a battery of individual difference assessments – including assessments of neuroticism, extraversion, intelligence, and Type A Behavior Pattern – to college students, and looked at how the assessments correlated with performance on laboratory MT environment tasks both in terms of accuracy and persistence. Contrary to results found in some of the other studies, there were no significant correlations found between MT performance and the individual difference variables measured. One possible explanation for the seeming lack of consistent findings involves the nature of the MT environment used in the various studies. In the Delbridge study, for example, participants had no choice about when to switch tasks: timing was pre-determined by the experimenter. Furthermore, participants were allowed frequent breaks, and the tasks were all very different, with very little overlap or chance of interference. The difference between the findings of these studies and the findings of other studies (e.g., Conte & Jacobs, 2003; Gonzales, 2004; Heil, 1999; King, Retzlaff, Detwiler, Schroeder & Broach, 2003; Miyake, Friedman, Emerson, Witzki, Howerter, and Wager, 2000; Suss, Oberauer, Wittman, Wilhelm, and Schulze, 2002) suggest that that perhaps in order for individual differences to play a role in MT performance, the MT environments need to either elicit a certain level of stress and/or emphasize specific demands.

The correlational studies examining the effect of individual differences on MT performance provided insight into traits that are desirable across a wide variety of MT environments. Those who score higher on assessments of fluid intelligence, processing speed, working memory, are likely to perform better in MT environments (Jerneic & Sverko, 1994; Cepeda, Kramer & Gonzales de Sather, 2001; Suss, Oberauer, Wittmann, Wilhelm & Schultze, 2002; Gonzales, 2004)), but the question still remains – will those people perform equally well in all types of MT environments? That is, might some individuals who score high on a particular individual difference measure perform well in some MT environments, but not others?

A few studies examined the interaction between individual differences and characteristics of the environment. Of these, most focused on how personality traits interacted with differences in MT environments. One such set of studies (Ishizaka, Marshall, & Conte, 2001; De la Casa, Gordillo, Mejias, Rengel, & Romero, 1998) looked at the interaction between the personality dimension, Type A Behavior Pattern (TABP), and explicitness of task prioritization. Participants were given a series of tests designed to assess TABP. They were then given multiple tasks to perform, such as memorization, visual search, quantitative comparisons, and gauge monitoring. In some of the conditions, task prioritization was explicit – participants were told which tasks were primary and which were secondary. In other conditions, they were told nothing about the relative importance of the tasks. The primary findings of these studies revealed a distinct interaction between TABP and the explicitness of task prioritization: In environments where it was not clear which of two tasks takes priority, those classified as Type A tended to be “hypervigilant” and divide their attention equally between the two tasks, while those not classified as having TABP tended to focus on one task more than another. In situations where the primary task was clearly defined, however, those classified as Type A were better able to direct attention toward the relevant primary task and not be distracted by the secondary task. Based on results of these studies, the researchers suggested that some individuals may be better suited to work in MT environments where task prioritization is relatively stable, while others may be better suited to work in environments where task prioritization is constantly shifting or may suddenly change.

A handful of other studies looked at more cognitive individual difference variables, such as the study conducted by Cepeda, Kramer, Gonzales de Sather, (2001). This experiment looked at how individual difference factors such as working memory capacity, processing speed, and age interacted with MT performance involving tasks with varying levels of interference potential (i.e., tasks that shared varying degrees of similarity). Findings indicated that age was a primary factor, but working memory capacity and processing speed also explained some of the variance. The differences were more marked as task interference increased.

A relevant issue addressed in several studies concerns the stability of the interaction between individual differences and environmental characteristics. Is the correlation strong during initial training, but becomes less relevant as a person receives more training and becomes more familiar with the tasks? Ackerman (1992) addressed this question in a study in which he looked at how cognitive ability, perceptual speed, and psychomotor ability predict performance on MT tasks that have either consistent or inconsistent (i.e., predictable or unpredictable) processing demands. Results indicated that during the initial learning phase, the correlation between the individual difference variables and performance was high for both consistent and inconsistent tasks, but that as people became more familiar with consistent tasks, the correlation became attenuated. This indicates that some people may do well in MT environments when the rules and procedures are fairly predictable and the information processing demands are consistent, but then have difficulty – even after hours of practice and training – in MT environments where some or most of the tasks are not predictable.

Along similar lines, Damos and Smist (1982) looked at the different strategies people used to manage the flow of tasks in a dual task laboratory study requiring speeded responses. Not surprisingly, they found that there were clear differences in the types of strategies that individuals used, with some strategies being far more efficient and effective than others. Those who did well on the task tended to first analyze the environment and set up response patterns enabling them to offload some of the cognitive workload demands and quickly switch between tasks. Others tended to use a more "massed" approach, focusing on one task at a time while ignoring the other task for long periods of time. What was interesting, though, was that even when those who used the less efficient "massed" strategy were asked to adopt the more efficient strategy, they were, for the most part, unable to do so. Therefore, it appears that performance in the MT environment was not due solely to training or choice of strategy, but to an underlying ability.

Based on the review, a list of cognitive and personality variables was distilled that have been shown to effect performance in MT environments and appear to have the most practical value. The variables on the list shown in Table 1 have been linked to specific environmental demands, and other researchers have identified their relationship to performance in multi-tasking conditions.

Table 1:
List of Key Individual Differences Related to MT Performance

Cognitive Variables	**Personality**
attention allocation strategy	complacency potential
baseline arousal levels	conscientiousness
ability to coordinate information	coping style
divided attention	decisiveness
fluid intelligence	impulsivity
inhibition (suppressing responses)	locus of control
interval timing ability	mastery orientation
managing large sets of goals	openness to experience
mental set switching speed	organization
motor response speed	performance orientation
perceptual accuracy & discrimination	risk taking
perceptual processing speed	tolerance for high intensity activities
planning	tolerance of ambiguity
prioritization	trait anxiety
prospective memory	Type A Behavior Pattern factors
reasoning about abstract concepts	– Achievement strivings
recognizing abstract relationships	– Impatience/irritability
retrospective memory	– Polychronicity

selective attention situational awareness working memory capacity & updating	– Sense of time urgency

Table 2:
List of Key Environmental Variables Related to MT Performance

I. Environmental Variables

A. Number of tasks performed in a given time period (few vs. many)
B. Number of information sources monitored in a given time period (few vs. many)
C. Frequency of interruptions (few vs. many)

II. Task Coordination Variables

D. Explicit Priorities vs. Ambiguous Priorities (whether the relative priorities of the tasks – which tasks are primary, which are secondary – is pre-established or if the worker must establish priorities)
E. Cued vs. Self-Determined Task Switching (whether when to switch to a new task is determined or signaled by the environment or is at the discretion of the worker)
F. Rapid vs. Relaxed Task Switching (switching every few seconds or longer time periods)
G. Erratic vs. Consistent Task Switching (whether pacing is fairly steady or if there are lulls interspersed with periods of high intensity)
H. High vs. Low Similarity Among Tasks (whether tasks share characteristics that might be easily confused, or are quite distinct)
I. Dependence or Coordination vs. Independence of Tasks (whether the ability to do one task depends on completion of another or if the tasks are independent from one another)

III. Task Variables

J. Short vs. Long Average Task Duration (whether tasks can be completed within seconds or if they take hours to perform)
K. Little vs. Extensive Training Required
L. Automatic vs. Choice Decision Making decisions have prescribed responses that become automatic with experience or have multiple potential solutions that require choice decisions.)
M. Severe vs. Little Consequence of Failure (On one end of this dimension there is little or no consequence to failing to perform the tasks correctly or at all. On the other end of the dimension, there are extreme consequences)
N. Speed vs. Accuracy in Performance of Tasks (On one end of this dimension, tasks must be performed at the highest speeds possible. On the other end of the dimension, all tasks must be performed at high levels of accuracy.)
O. Multiple Different Tasks vs. Multiple Similar Tasks (whether the different tasks require multiple kinds of skills -- e.g. communication, social, perceptual motor, cognitive, etc -- or the tasks require similar and a limited set of skills
P. Constant vs. Periodic Monitoring Required (whether constant monitoring is required or if the monitoring task may be performed periodically.)
Q. Type of Task (such visual or auditory monitoring, motor response, choice reaction,

etc.)

As noted previously, the literature review also included sources that described the effects of environmental variation on MT performance. Based on the review, a list was compiled of dimensions upon which MT environments likely vary. The compilation focused on the variables that other basic and applied researchers have investigated, that seem the most important characteristics of MT environments, and that seem the most relevant to potential individual differences. Table 2 organizes the environmental variables in three categories: those that characterize the environment itself, those that distinguish how tasks must be coordinated, and those that describe the tasks themselves.

The lists of individual and environmental variables extracted from the literature were not sufficient to develop a model of MT environmental variation, nor link that variation to individual differences in abilities. The literature on this topic is fragmented and researchers have not yet developed a comprehensive model of MT environments, nor have they attempted to determine the relative importance of individual difference variables. The literature review did, however, provide an initial framework on which to base further study of the factors that affect MT performance. Based on research findings, the lists afforded the development of empirically supported hypotheses about how different environments and different workers vary. The lists were also used, in part, to design a study in which interviews were conducted with SMEs who work in various MT and non-MT environments. Specifically, the lists were used to guide the development of an interview instrument that was administered via telephone interviews with subject matter experts in a selected set of Army MOS's. The following section describes the methods and results of that study.

STUDY OF VARIATION AMONG MT ENVIRONMENTS

The purpose of the interview study was to better understand the variation among MT environments, how MT environments differ from non-MT environments, and how individual differences affect performance in MT environments. While the literature review was useful in generating hypotheses, it was necessary to take the next step, which was to explicitly investigate variation among environments thought to demand MT to varying degrees. The first step of the study was to select a set of Army MOSs that covered a wide range of domains from health care to food services, and also appeared to entail differing levels of MT. Selection was initially based on brief written descriptions found in Army literature (US Department of Defense, 1993; http://www.goarmy.com/JobCatList.do?fw=careerindex and http://usmilitary.about.com/od/enlistedjobs/a/arjobs.htm).

One of the primary purposes of the interview study was to gather detailed descriptions of each MOS, particularly in terms of the dimensions that the MT literature indicated played a role in effecting differences in MT performance. For example, the interviews addressed issues concerning prioritization demands, task-switching frequency, and level of decision-making autonomy that characterized the MOS's. The goal was to compile the information in a format in which similarities and differences across the various MOS's could be revealed. The intent was to discern any patterns of variation that should be included in a model of real-world MT environments.

Method

Participants. Ten individuals were recruited as participants for the interviews. Each individual was highly experienced in one of ten MOSs that were selected for analysis: Air Traffic Controller (15Q), Communications Locator/Interceptor (98H), Electronic Intelligence Interceptor/Analyst (98J), Fire Support Specialist (13F), Food Service Operations (92G), Health Care Specialist (91W), Multichannel Communication Systems Operator (25Q), Radiology Specialist (91P), Transportation Management Coordinator (88N), and Topographical Analyst (21U). Based on recommendations of experienced Army Personnel, these MOS's were selected because they appeared to represent a wide range of domains, as well as varying levels of MT. Several participants were recruited upon the recommendation of personnel from the U.S. Army Human Resources Command. Others were recruited from previously established contacts. A total of ten SMEs were interviewed. All of the participants were SFCs, MSGs, or SMGs and had several years of experience performing and/or supervising in their particular MOS. Many of them were currently serving as professional development coordinators.

Materials. Drawing upon the environmental factors identified above, which the literature review and our own previous analysis of MT environments (Fischer, Morrin, & Joslyn, 2003) had shown to be potentially useful, an interview instrument was created to tap into the environmental characteristics of each MOS, as well as the MT demands and the individual difference traits of individuals who functioned well in that particular environment. Appendix A contains the survey instrument used in the study. As can be seen in Appendix A, the interview instrument included quantitative questions, such as the number of tasks performed in a given time period; rating questions, such as rating on a scale of one to five how explicit task prioritization is, with one being very explicit and five being not at all explicit; and open-ended questions such as, "What distinguishes a top performer from one who has difficulty?" Each question also included examples, prompts, and follow-up questions that the interviewer could use when necessary.

Procedure. Individual 30-50 minute phone interviews were conducted with each SME participant. The interviewer first described the purpose of the study, then asked the participant about his or her background in the MOS. The interviewer also asked the participant how he or she would define multi-tasking to ensure they understood what was meant by the term as it was used in the survey. The interviewer then asked a series of questions, contained in the interview instrument, addressing such factors as number and type of tasks, number and types of sources of information, memory demands, task switching frequency, task switching initiation, task continuity, task prioritization, level of decision making, level of decision-making autonomy, degree of task urgency, consequences of failure, and characteristics of individuals who do well or poorly in that environment. The interviews were recorded on audio tape.

Results

The interview responses were summarized and recorded in several tables, which are contained in Appendix B. The tables show a great deal of variability among the ten MOS's on most dimensions. That said, patterns did emerge from the data. Some MOS's appeared to emphasize certain environmental and individual difference characteristics more than others. For example, in MOS's where the environment was often unpredictable and task prioritization somewhat flexible, traits such as ability to think fast, make independent decisions, take initiative, and learn quickly were frequently mentioned. In more routine environments where task prioritization was usually pre-established, traits such as time management and organizational skills were more frequently mentioned. There was, of course, overlap in the SMEs' responses. The ability to "think on one's feet," for example, is desirable across all jobs.

Patterns also emerged from the information that respondents emphasized as most important to their working environment. Three different dimensions were most salient in the data. First, there appeared to be differences among environments in terms of the *type* of multitasking required. Some environments appeared to primarily focus on *rapid assessment and decision-making* in non-routine situations. An example of this might be the Fire Support Specialist MOS, where Soldiers have to, among other things, gather and coordinate information to determine what is the best action to take, as well as when, where and how to best carry out that action. Although there are usually established procedures with which the Soldiers are well-trained, the environment is often unpredictable and ill-defined; this requires the Soldier to quickly assess the situation, weigh the relative values of various options, and then select the best possible plan of action.

In contrast, other environments seemed to primarily involve *maintaining task flow*. A good example of this type of environment was the Food Service Operations MOS, where there are several routine ongoing tasks or "projects" occurring at the same time. Although the Soldier must still be able to handle unexpected events, typically the environment is predictable and well-defined. In this type of environment, a Soldier's primary responsibilities include initiating tasks at appropriate times, frequently checking on the progress of the tasks or projects, and coordinating the timing of task execution.

A third type of MT environment appeared to involve *monitoring, coordinating, and responding to information flow*. SMEs who described this kind of environment frequently talked about the integration of information. A good example of this kind of environment was the Electronic Intelligence Interceptor/Analyst MOS, where a Soldier must monitor multiple sources of information, learn to allocate their attention appropriately, and learn to recognize patterns.

The three types of environments appeared to place differing emphasis on the ability to prioritize, make decisions, and manage time. They also appeared to vary in terms of how much autonomy the Soldier has in a given situation, and how much cueing the environment provides. Hence, there appears to be a set of environmental dimensions that distinguish environments in ways that place different demands on individual capabilities and performance.

A second dimension that appeared to distinguish MT work settings was intensity or pacing. Jobs seem to vary in terms of how many tasks must be performed in a given time period, which may be measured by the frequency of task switching and interruptions. In some situations, the Soldiers may switch tasks every few seconds; in others, it may be every few minutes – or longer. Some have time to at least partly finish one task before moving on to another, while others are frequently required to drop and pick up tasks midstream.

A third dimension upon which MT environments appeared to vary was the severity of consequences of failure to perform the job correctly. In some MOS's, such as Health Care Specialist, Air Traffic Control Operator, and Fire Support Specialists, failure to successfully multi-task could result in loss of human life. In other MOS's, the normal and expected consequences of failure are less severe – such as loss of information or material resources, damage to equipment, or inconvenience to others. While it is true that these less severe consequences could also conceivably lead to loss of life (e.g., the lost information might have been critical in preventing an attack), the consequences are less immediate and can sometimes be ameliorated. Variation in consequences may have significant effects on individual MT performance. For example, a particular person might be excellent at MT – unless lives are at stake, at which point the level of stress might inhibit performance. Preoccupation with the consequences of failure might demand extensive cognitive resources such that it impedes the ability to multitask.

A MODEL OF MULTI-TASKING ENVIRONMENTS

Information that was gathered from the literature review, SME interviews, and our own previous research was used to create a model of how MT environments differ from one another, and how they differ from non-MT environments. The relative contributions of these three sources of inspiration for the model cannot be quantified. However, the information extracted from the literature review of MT environmental variation was far more productive and had greater influence on the model than did information extracted from the literature on individual differences. Manipulation and comparison of the effects of environmental conditions ultimately provided a framework on which modeling efforts could be based. In contrast, the literature on individual differences was less useful, largely because it is fragmented. Studies have typically focused on single personality or preference variables and have not attempted to relate these variables to other kinds of factors, i.e., environmental factors. No comprehensive model of MT ability has been developed. In short, the individual difference literature was not as helpful to the model building effort as initially expected. In contrast, study of environmental variation (from the literature and from the SME interviews) produced results that could be immediately applied to modeling objectives.

The literature on individual differences also leads to an impractical measurement approach for assessing MT ability. The fragmented nature of the individual difference literature lends itself to an unfeasible assessment strategy in which a battery of tests is used, each test specific to one individual difference factor. A battery of tests would most certainly take several hours to administer, which would be costly and unworkable for most applications. In contrast, the literature concerning environmental differences between laboratory and real-world MT conditions leads to a much more pragmatic testing approach in which key environmental variables that draw out the important individual differences are simulated. Such an approach, of course, requires a theoretically grounded and empirically tested model of environmental variation among MT settings, which must also be related to key individual difference variables that determine performance in those settings. Hence, a goal of this research was to develop just such a model.

Only a few researchers have attempted to define real world MT environments or distinguish them from other kinds of work settings (Burgess, 1998, 2000; Joslyn & Hunt, 1998; Fischer, Morrin, & Joslyn, 2003). The few theoretical and empirical studies that can be found in the literature have focused on the commonalties among real world MT environments and have offered definitions of these types of work settings. For example, Fischer, Morrin, and Joslyn (2003) proposed that MT work environments share eleven characteristics: they (1) have multiple discrete tasks, (2) require that tasks must be interleaved and cannot be performed simultaneously, (3) require that tasks cannot be shed or significantly postponed, (4) do not signal or cue task initiation, (5) are dynamic and include interruptions, (6) present tasks that differ in priority, difficulty, and time needed for completion, (7) do not provide feedback for some tasks, (8) require that tasks be performed in seconds to minutes, (9) are time pressured, (10) include tasks that demand different kinds and amounts of cognitive resources, and (11) require extensive training or education. The model presented in this report extends previous conceptions of MT environments by describing how they vary from one another in ways that are important to individual differences among the workers who perform these jobs.

The model also clarifies previous researchers' (Burgess, 1998, 2000; Fischer, Morrin, & Joslyn, 2003) conceptions of how MT environments are different from non-MT work settings. Specifically, the model states that MT work environments should be distinguished from jobs that are simply fast-paced. Work environments frequently require personnel to perform more than one task within a limited period of time. In some jobs, workers have to quickly complete one task before they turn to another. The next task must then be swiftly completed before yet another task is started, and so on. The requirement to sequentially complete tasks under time constraints creates a fast-paced environment. However, a useful distinction can be made between work environments that require quick sequential completion of tasks and those that are also fast-paced, but require task execution to be interleaved. The requirement to interleave multiple tasks under time constraints has been identified as a key distinguishing characteristic of multi-tasking (MT) environments (Burgess, 1998, 2000; Fischer, Morrin, & Joslyn, 2003). This distinction is important because the demand to interleave tasks requires different cognitive capabilities than does the demand to sequentially complete tasks. For example, heavy demands are placed on workers' prospective, short-term, and working memory when interleaving tasks because they must remember to reinitiate tasks that have been temporarily suspended.

The model proposes that the variance among MT environments is multidimensional. That is, real world environments vary in many ways, along many different factors. Some dimensions on which MT environments vary have the result of placing different demands on workers, while other dimensions do not. For example, the *kind of tasks* the worker is required to perform varies among MT environments. Some environments present workers with ill-defined problem spaces, within which they must make rapid decisions. Others present problems that have routine solutions, but require workers to perform multiple interleaving actions. Figure 2 shows a two-dimensional representation of several environmental dimensions that the present research suggests are important and influential factors that characterize real-world MT environments. These differences probably demand varying cognitive, physical, and emotional skills. Figure 2 is, of course, somewhat misleading because of the necessary reduction to a planar view.

As noted previously, the present research suggests that key environmental variables of MT work settings co-vary in systematic ways. For example, consider the following environmental dimensions.

- ill-defined problem space vs. well-defined problem space
- multiple potential solutions vs. single potential solution
- freedom to prioritize tasks vs. environmentally determined prioritization
- autonomous task switching vs. environmental cued task switching

The results of the interviews conducted in the present research suggest that these dimensions cluster to form different types or kinds of environments. For example, environments that present ill-defined problem spaces also typically require the worker to prioritize tasks and self-determine when they will switch to another task. These types of environments typically place heavy demands on situation assessment and rapid decision-making capability. Conversely, other jobs that present problem spaces that are well defined and have only one acceptable solution also tend to provide inviolable prioritization of tasks, and task switching is often environmentally cued. The effect of the covariation among the multiple dimensions on which environments vary is to create types of MT environments. Therefore, it is possible to derive a typology of MT environments that captures many important differences among the environments, particularly differences that place different kinds of demands on workers.

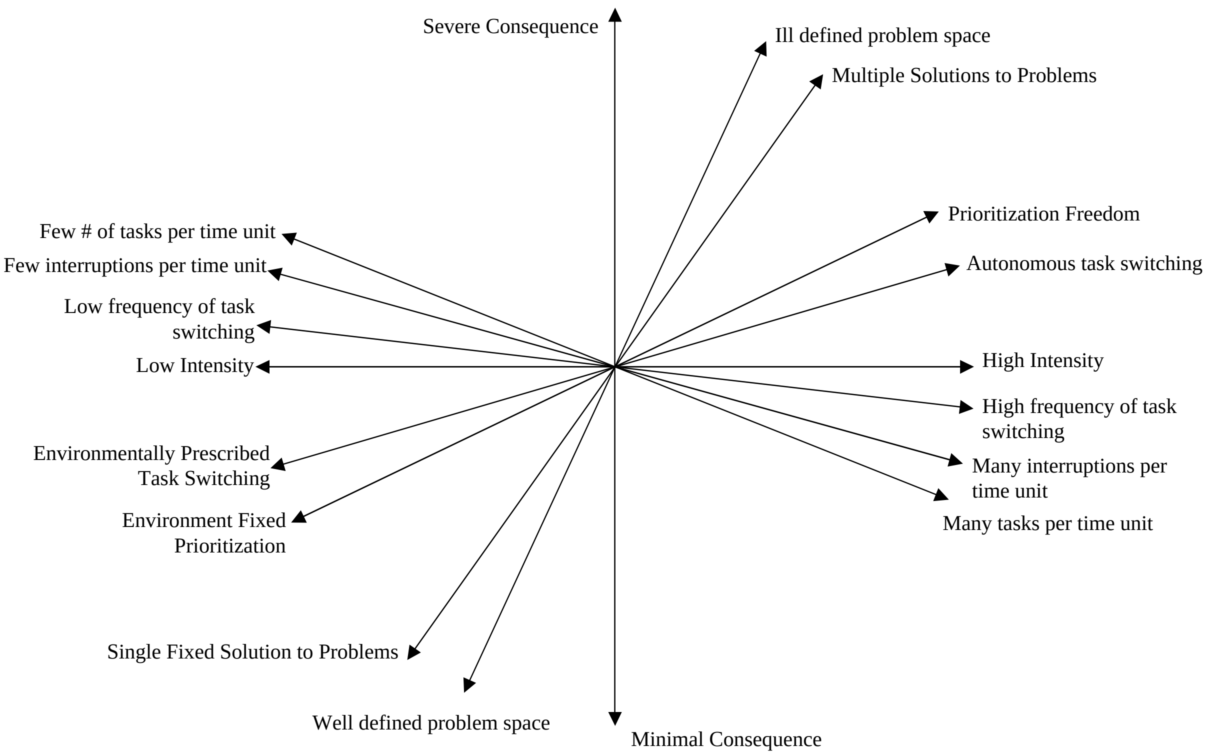


Figure 2. Multidimensional space characterizing variation in MT environments.

There are probably a smaller set of key variables or sets of variables that have the greatest effect on the kinds of capabilities workers must have in order to perform well in the environment. One of these is the consequence of error or failure. While no one likes to fail, failure in some environments is less consequential (e.g., food preparation) than in others (e.g., nursing, artillery fire support, or air traffic control). Variation in the severity of consequence among MT environments probably affects worker-perceived stress levels, willingness to perform the job, and attrition. Hence, variability among environments in terms of the consequence of failure probably interacts with certain individual characteristics. Environments that present high consequences demand the worker be at least emotionally stable, resistant to stress, and confident, among other individual characteristics.

As noted previously, a second dimension that distinguishes MT environments is the *intensity* of multi-tasking required. Some MT environments simply require more tasks per unit time, are faster paced, or present more uncontrollable interruptions. The intensity of the environment probably influences the required MT skill level a worker needs. Individuals with moderate MT abilities may do well at moderate intensity jobs, but are likely to perform poorly at jobs that are at the highest levels of intensity. Again, variation in intensity most likely covaries with certain individual differences to affect overall performance. Workers in high intensity environments probably have to have a large working memory capacity, excellent organization skills, good prospective and short-term memory, and good logic and reasoning skills, for example.

A set of environmental variables that involve the *kind* of tasks required by the environment constitutes another group of important dimensions. These include complex vs. routine decision making; freedom and responsibility to prioritize vs. prescribed prioritization; ill-defined problems with multiple solutions vs. well-defined problems with only one or few solutions that satisfy constraints; and autonomous vs. environmentally cued or forced task switching. As noted previously, particular values of these dimensions most likely co-occur in real-world MT environment, which has permitted us to identify three general types or kinds of MT environments. Based on the likely covariation of these variables, an initially simple, but testable, typology of MT environments is offered.

The first kind of environment described by the model requires high levels of decision-making capability. Environments that tend to require complex decision-making also tend to provide freedom and responsibility in prioritizing. Such environments also tend to present ill-defined problems for which there may be multiple solutions that satisfy constraints. The central task in such environments may be to allocate limited resources. Company commander and fire support specialist (field artillery) are two good examples of this kind of MT position.

The second kind of environment presents workers with well-defined problems that require routine decision-making. In such environments, the worker learns a set of “canned” solutions to the problem. Task switching is often cued by the environment in these jobs, and hence, prioritization of tasks is well defined. The main MT issue in this second kind is to keep all of the many tasks going and manage the task flow – or keep all the balls in the air, if you will. Some nursing positions (e.g., floor nurse in some hospital departments) and food service positions are examples of this kind of environment.

A third kind of MT environment identified by the model is characterized by its multiple sources of information. The sources may provide information in auditory, visual, or tactile mediums. The worker’s job in this third type of environment is to monitor and respond to multiple inputs or to integrate the various sources of information to derive meaning. The characteristics of the three kinds of MT environments are described in greater detail in Appendix C.

The model of MT environments, depicted in Figure 3, identifies three key orthogonal dimensions. Figure 3 displays three kinds or *types* of environments, as described above, which form one categorical dimension. The three types are shown as the “pie slices” in the figure. The second dimension identified by the model is the *intensity* of MT activity. Intensity of each of the three kinds of environments varies from low to high. High intensity environments are depicted in Figure 3 as the darker saturated center regions of each circle. The outer rings of the circles represent low MT intensity environments. It is important to note that the outer rings of the model do not represent non-MT environments and the model does not attempt to describe those kinds of work settings. The model is therefore limited to the domain of MT; its boundaries exclude work domains that do not meet the definition of MT it proffers. If one were to depict non-MT environments in Figure 3, one would have to place them outside of the shaded rings. The third orthogonal variable identified in the model is the *consequence* of error or failure in the environment, ranging from minimal consequences to severe consequences. This is represented in Figure 3 by the multiple and layered circles, with the circles in the rear portion of the figure having minimal consequences and the ones toward the front of the figure having severe consequences.

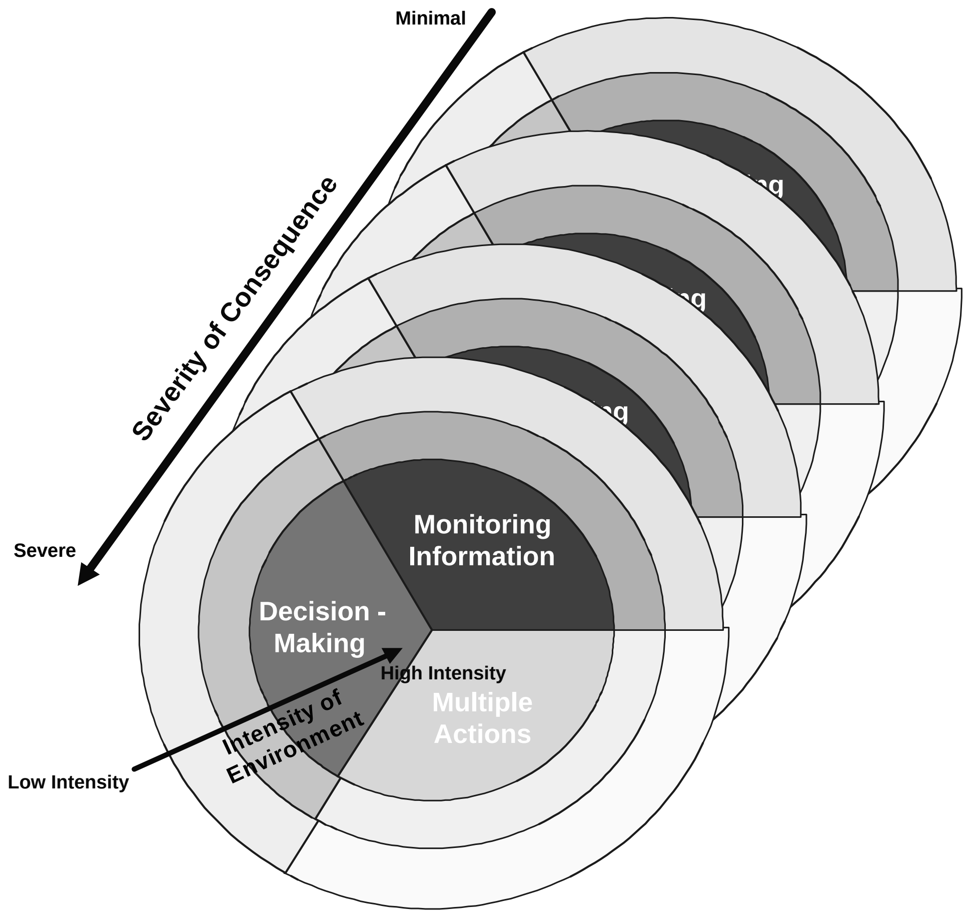


Figure 3. Depiction of model of MT environments.

As will be discussed in the measurement approach below, these three orthogonal dimensions can be directly linked to specific factors that characterize differences in MT environments, such as timing interval between task, level of autonomy, and degree of established prioritization that, in turn, have been shown to draw out individual differences in performance. Thus the model not only provides a structured description of MT environments, it can also be used to guide the design of tests that can be tailored to predict performance in particular MT work environments. In the following section of this report, a measurement approach for assessing MT ability is discussed, which was developed based on the model shown in Figure 3.

A MEASUREMENT APPROACH FOR ASSESSING MT ABILITIES SPECIFIC TO VARYING MT ENVIRONMENTS

The findings of Tasks 1 and 2 were used to guide the design of a measurement approach, which could be used to evaluate multitasking ability in a wide variety of environments. The measurement approach is actually a relatively complex assessment system, which we refer to as the *Multi-Tasking Assessment System (MTAS).* The proposed measurement approach not only assesses individuals' MT abilities, but also assesses work environments to determine (1) whether an environment qualifies as an MT work setting and (2) the kinds of MT demands they place on workers. Figure 4 shows that the MTAS consists of two main components: the Environment Assessment Tool (ENVAT), which assesses the MT requirements of work environments, and a test component that includes three basic versions of the Multi-Tasking Ability Test (MTAT), each of which assesses individuals' performance in a particular type of MT environment. The testing component also includes three sub-versions of each MTAT test, which are adaptively administered and are designed to tap performance differences associated with environmental variation at three levels of intensity. Therefore, the system actually includes nine test instruments.

The system's design (MTAS) is predicated on the notion that the highest predictive capability can be obtained by first assessing the environment of concern and the demands it places on individuals. Once the important characteristics of the environment are known, then individuals can be tested to determine whether their skills match the demands of the environment. Figure 4 shows that information gleaned by the environmental assessment component is used to select the most appropriate version, or multiple versions, of the MTAT to administer to individuals. The environmental assessment, combined with an individual's MTAT test results, is used to predict how an individual will perform in that particular environment. The MTAS produces a variety of products that contain needed information to the purpose of selection or placement. Representatives of the organization using the MTAS would first be provided with profiles of the environment of interest. Figure 4 shows that the ENVAT's output includes a job environment report (see top right box of Figure 4). A variety of scores and information about the performance of each test taker would also be provided to the organizational representative. Raw scores, percentile scores, written synopses, and expectancy charts would be produced by the MTAS to describe individuals' performance (See lower right box of Figure 4). Each component of the MTAS is explained in greater detail below.

Environmental Assessment Tool (ENVAT)

Assessment of the multi-tasking work environment would be conducted using a brief, web-based survey called the ENVAT (see upper left box in Figure 4), which must be completed by a test administrator who is well experienced with the environment of concern, or a qualified subject matter expert. The individual must be thoroughly familiar with the particular work environment and must be able to articulate the job demands of that environment using the ENVAT. The ENVAT would consist of a series of scales corresponding to key dimensions on which environments vary. In combination, the scales would be used to assess what *type* of environment the job entails, as well as the level of MT *intensity*. Questions that relate to the type of MT environment would focus on dimensions such as how well-structured the environment is, the explicitness of task prioritization, the level of autonomy in decision-making, and the types of tasks that are performed. Questions that pertain to MT intensity would focus on dimensions such as the number of tasks that are typically carried out per given unit of time, the degree of urgency, the number of sources of information, task-switching frequency, and so on. To ensure reliability and validity of each dimension, questions could be asked in a variety of ways, such as multiple choice, scaling, and other formats. Table 3 provides examples of question formats that could be utilized in the ENVAT.

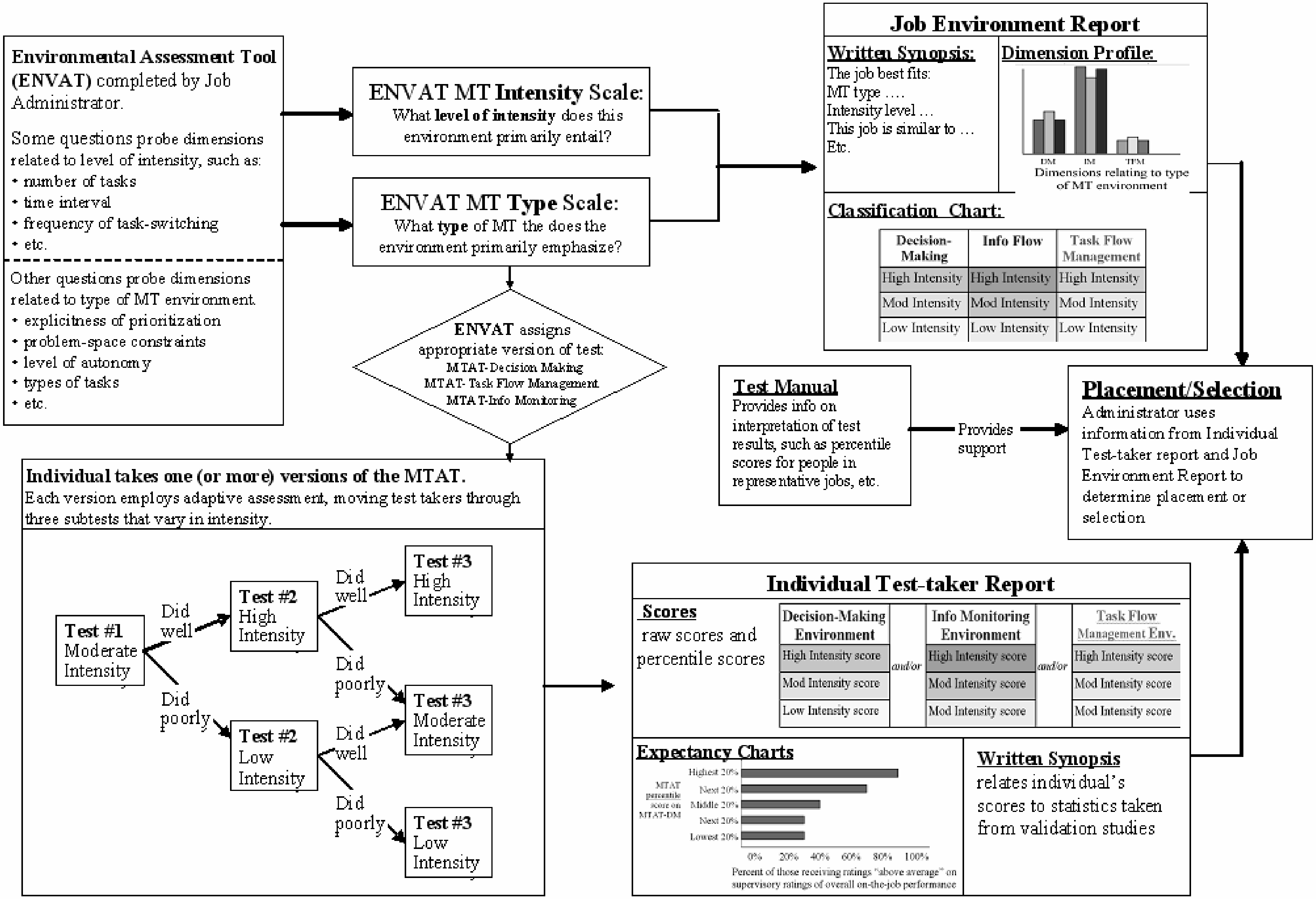


Figure 4. Multi-Tasking Assessment System (MTAS) Overview.

Table 3.
Potential Question Formats for the ENVAT

♦ Which of the following descriptions BEST describes the general work environment:
A) Keeping many ongoing activities or projects running at the same time, etc. For example, …
♦ Which of the following jobs is most similar to the work environment, not in terms of content, but in terms of general pacing, types of tasks, etc.
A) Job X, where the person does ….. etc.
♦ Read the descriptions of the three job candidates below. Which one would be a best fit for the MOS?
A) Job Candidate A is good at X, but is not good at Y. His/her supervisor noted…etc.
Highly specific questions could also be asked, such as:
Think of a period where someone in this position is engaging in a high level of MT. On average, how many tasks are they performing at the same time?

The questions would be carefully tested in order to ensure that they are understandable and provide useful information about the dimensions of a particular MT environment. Environmental consistency issues would also be addressed in the ENVAT. If, for example, some environments vary in type of MT, intensity, and even severity of consequence *within* themselves, the ENVAT would account for that variation, selecting the method that would produce the most accurate performance predictions. As is depicted in Figure 4, once the environment has been defined along key dimensions, the next step is to assess individuals' MT abilities in order to determine if they match the demands required by the environment.

Testing Component of the MTAS: Assessment of MT Abilities

Figure 4 shows that the test component of the proposed MTAS comprises three tests, purported to predict performance in the three different types of MT environments described in the model (See lower left box of Figure 4). The test component of the MTAS would include high, medium, and low intensity versions of each type of test. Depending on input from the ENVAT that describes the requirements of a candidate environment, one or more of the tests would be administered to a target population for the purposes of selection, placement, or even general information to increase self-awareness.

The intensity versions of the MTAS will assess how well an individual can perform in MT environments of varying intensity. The MT literature, as well as comments made during our interviews with SMEs, indicates that intensity or pacing of the environment plays a definite role in affecting individuals' performance in a particular environment. For example, some individuals may function well in positions such as a signals interceptor/analyst when the incoming information is coming in at a moderate pace, but as the pacing increases, their performance begins to break down. Others, however, appear to thrive in fast-paced environments, and are able to adjust to the increasing demands.

An adaptive approach to assessing capability associated with intensity would be incorporated into each of the three versions described above. For example, Test #1 might have a moderate task interval of perhaps 30 seconds. Based on how well the user performed at that interval level, the computer would then select the interval level for the second test. Test #2 would then present tasks at either a 15 second or a 45 second interval. Test #3 would also either increase or decrease the timing interval by a fixed amount depending on how well the individual did on the previous test. The appropriate timing levels and the criteria for increasing and decreasing them would be determined by data obtained in the validation studies. One advantage of using an adaptive approach with intensity level is that it will give users time to learn the environment at a slower pace before moving to a more intense level, and it will provide greater flexibility in testing. If a person performs quite adequately at a moderately paced environment, but has difficulty performing in a higher-paced one, then the assessment will reveal that; there is no need to have him or her sit through a high-paced version of the test.

As previously discussed, we propose that the most efficient and effective way to assess MT ability for multiple environments is to simulate those environments in a performance-based assessment of multitasking, such as that used in the MTAT. This is in contrast to a strategy that administers a battery of individual tests that each addresses a particular individual difference variable associated with MT performance. The MTAT simulates many aspects of a complex, fast-paced MT environment by requiring users to simultaneously apply many of the skills commonly demanded by MT environments, such as allocating attention efficiently while prioritizing tasks, remembering results of past actions, and remembering to carry out future actions. Furthermore, the MTAT can be modified to increase cognitive demands relating to specific types of MT and to differing levels of intensity. In the following section, we provide specific information about how the MTAT would be modified to create a battery of tests that can be used flexibly to predict performance in different MT environments that vary in type and/or intensity.

Creating Different Test Types Based on MTAT Variations. The MTAT environment is ideal for simulating variation in MT environments. Research has shown that Type A Behavior Pattern (TABP) is related to performance in MT environments, and variation among environments. It turns out that people high in TABP respond differently to environments that have clear task prioritization rules than to environments that present ambiguous prioritization rules (Lieberman & Rosenthal, 2001; De la Casa, et. al, 1998). Knowing the relationship of performance to TABP, one testing strategy would be to administer a test of TABP to predict whether a person might do well in an ambiguous environment. But, instead of administering a typical Type A Behavior Pattern assessment tool as a measurement approach, such as the Framington Type A Scale, one could instead create a version of the MTAT where prioritization rules are ambiguous and another version where they are explicit, then look at how well individuals perform in those two environments. The underlying mechanism behind performance differences may be due to a mixture of Type-A personality type, differences in attentional allocation strategy, and inhibition. But rather than address these variables individually, it is far more efficient to simulate environments that draw out these differences, and then analyze their performance patterns.

The MTAT is essentially a computer-based, abstract simulation of an MT environment. It involves presenting the user with a series of objects that they must correctly classify into one of four bins based on features of the object such as its size, shape, and color. The users are never shown the bins, they are just told which features the bins accept (such as “red circles of any size”, or “tiny, blue, triangles”). They are also never shown the objects. They are just told, periodically, that a particular object is available. To complete the object classification task, the user must perform a series of subtasks – mainly initiating queries – that provide information about the features of a particular object. At the same time, they must also note, remember and keep track of which objects are available and which are in need of classification. What makes the simulation an MT environment is that at any one point in time, the user typically has multiple objects available to be classified, and more appear on a regular basis. The MTAT shares many features that are common to MT environments, and, as previously noted, is highly predictive of performance in simulations of MT environments such as emergency dispatching and air traffic control. One main advantage of the MTAT is that, unlike these more concrete simulations, it does not require prior content knowledge, and the entire test, including practice and training, takes less than 30 minutes rather than several hours. Thus it is an ideal test to use in selection and placement of personnel into MT environments.

Previous research analyzing civilian MT environments (Fischer, Morrin, & Joslyn, 2003), review of the MT literature, and preliminary analysis of our own interviews with SMEs has shown that the current version of the MTAT incorporates many features which address the variables that are critical to proficient performance in most MT environments. Table 4 lists some of the key environmental characteristics that are common to most MT environments, associated individual difference variables that underlie differences in MT performance, as well as features of the MTAT that tap into those differences.

Those who score well on the MTAT would probably function well in an environment that shares these characteristics, while those who score poorly would probably not do well. These variations in performance might be explained by individual differences in the cognitive and personality variables that are tapped by specific features of the MTAT. As the model of MT environments indicates, however, it appears that some MT environments may place greater emphasis on certain abilities than do other environments. For example, in an environment that is often non-routine, where task prioritization fluctuates, and there are multiple solutions or possible actions to select from, there is likely to be a greater demand placed on the ability to prioritize and rapidly assess situations than there would be in a more structured and routine environment. Therefore, to best predict performance in that environment, a test would have to emphasize those abilities. Likewise, some environments place greater demands on the ability to allocate attention effectively among several sources of incoming information. While the current version of the MTAT does tap into that ability (it would not be possible to score well on the test if one were not able to attend to multiple sources of incoming information), the demands might not be strong enough to discriminate among test takers who score at the high end; that is, differentiate among those who are skilled and those who are merely adequate, thus reducing the predictive power of the MTAT. For example, as was noted earlier, a previous version of the MTAT, the ADM, was able to explain 50% of the variance of dispatching simulation performances, but only 25% of the variance of air traffic control simulation performances. It may be that there are characteristics independent of MT, such as spatial ability, that contribute to differences in performance on the ATC simulation, but the lower predictive value may also be due to differences in the nature of the MT. In other words, ADM may incorporate more of the demands that are typical of emergency dispatching environments and fewer of the demands that are required by ATC environments, such as the ability to efficiently monitor several sources of information.

Table 4.
Match of Environmental and Individual Difference Variables to MTAT Features

Environmental Variable	Individual Difference Variable	MTAT Feature
Several tasks to perform within relatively short period of time	Mental set switching; prioritization	♦ alternate between specifying relevant object #; querying size, form, color; classifying objects, noting presence of new objects
Several different rules, procedures to learn	Retrospective memory capacity; ability to quickly learn rules and keep them straight	♦ remembering rules of the game ♦ remembering bin attributes
Several different cases (i.e., ongoing tasks, situations, or incidents) to keep track of	Retrospective memory, working memory, inhibition	♦ remembering which objects have been classified ♦ not confusing characteristics of current object with that of previous object
Interruptions: New cases appear prior to the completion of old ones	♦ working memory ♦ prospective memory ♦ selective attention ♦ prioritization	♦ must re-initiate current line of queries when new object appears ♦ must remember object number of current case (object they were querying) ♦ must remember which objects still need to be classified ♦ decide whether to continue with current object or attend to new one
Tasks are generally continuous (if interrupted, must pick up where one left off)	♦ retrospective memory ♦ mental set switching ♦ inhibition of prior info/responses	♦ appearance of new objects interrupts flow of queries, which must be re-initiated
Urgency	♦ processing speed ♦ tolerance of stress	♦ objects must be attended to or they lose points.
Task interdependence and sequence	♦ retrospective memory ♦ mental set switching	♦ ability to perform one task (assigning) depends on outcome of previous task (querying)
Rules and procedures may change depending on situation	Inhibition	♦ bin attributes change every test; must be able to inhibit old rules
Incoming information may be fragmented; needs to be integrated	Working Memory	♦ remembering and integrating results of queries (i.e., object attributes)

It therefore appears that the current version of the MTAT may not be sufficient to assess performance potential in the different types of MT environments outlined in our model, and thus will need to be modified. One option is to increase the predictive power of the MTAT by incorporating additional environmental demands into the assessment. Our prior research with the MTAT, however, has indicated that the assessment is already very challenging for most people. If too many additional rules and tasks are added, it could overburden the test-taker, resulting in poor performance for most of them, creating a floor effect, and reducing the predictive power of the test. Therefore, to increase predictive power, three different versions of the MTAT would be created, each corresponding to one of the three main MT environments identified in the model. Each version would have the basic structure of MTAT. That is, each would address the components that are common to all MT environments, such as the need to perform multiple tasks, fairly fast pacing, remembering to take future actions, deciding what action to take, and so on. However, each version would vary on how much emphasis it places on the key characteristics and corresponding abilities that distinguish the three MT environment types. For example, the Decision-Making environment involves relatively complex decision-making and greater autonomy in prioritization. Therefore, the version that correspond to the Decision-Making environment (MTAT-DM) would incorporate tasks and rules that places a greater emphasis on the ability to quickly assess a situation and select the most appropriate solution out of many possible solutions. The version that corresponds to the Information Monitoring environment (MTAT-IM) would require that the user monitor and respond to more sources of information. The version that corresponds to the Task Flow Management environment (MTAT-TFM) would require the user to handle multiple cases at the same time and to coordinate several ongoing tasks.

Table 5 provides examples of how each of the three versions of MTAT might vary. The first column lists some of the key environmental demands that are particularly emphasized by each of the three MT environment types outlined in our model of MT environments; the second column lists some of the individual difference variables that may underlie performance differences in environments that share those characteristics. Finally, the third column outlines some possible ways the MTAT might be modified to tap into those differences. As was previously noted, the relatively abstract nature of the MTAT allows it to be easily modified to incorporate additional tasks as well as more complex decision-making rules without altering the basic underlying structure or adding additional training requirements.

Table 5.
Environmental Variables associated with MT Environments,
Individual Difference Variables, and MTAT Features

Decision-making Environment		
Environmental Variable	**Individual Difference Variable**	**Possible MTAT Feature**
Ambiguous Prioritization	♦ Attention Allocation (Type A vs. Type B personalities) ♦ Tolerance of ambiguity ♦ prioritization	♦ have two tasks of varying value; priority depends on situation ♦ user can set prioritization
Resource Allocation Decisions	♦ retroactive memory ♦ prospective memory ♦ cognitive strategy ♦ planning ♦ reasoning ♦ working memory	♦ competing demands for same resource (either time, space, materials) ♦ differential value based on making most efficient allocation
Multiple solution/action options	♦ reasoning ♦ working memory ♦ fluid intelligence	♦ provide several viable options that change value depending on features of a particular situation
Autonomy in task switching	♦ proactive memory ♦ cognitive strategy	♦ requirement to initiate new tasks (rather than rely on environmental cues)
Unpredictable environment	♦ fluid intelligence	♦ rules or situations change independent of the user's actions
Rapid assessment	♦ fluid intelligence ♦ situational awareness	♦ several sources of information that must be combined to make assessment

Table 5 (Continued).
Environmental Variables associated with MT Environments,
Individual Difference Variables, and MTAT Features

Task Flow Monitoring		
Environmental Variable	**Individual Difference Variable**	**Possible MTAT Feature**
Several on-going tasks	♦ organization skills ♦ situational awareness	♦ requirement to switch between tasks/cases rather than complete one before moving to next
Scheduled Task-switching	♦ time management ♦ prospective memory	♦ need to adhere to established procedures
Somewhat routine decision making	♦ retrospective memory	♦ need to adhere to established prioritization/rules
Tasks and cases need to be checked on	♦ prospective memory ♦ attention allocation	♦ have several objects/cases that change over time
Information Monitoring		
Environmental Variable	**Individual Difference Variable**	**Possible MTAT Feature**
Many sources of incoming information	♦ divided attention ♦ attention allocation strategy	♦ have split screens or separate screens with different information sources that need to be integrated to successfully perform a task
Competing demands	♦ selective attention	
Information needs to be integrated	♦ reasoning	

Table 6 provides examples of some of the key environmental demands that relate to variations in MT intensity, as well as possible individual difference variables that may underlie disparities in performance and possible ways the MTAT might be modified to tap into those factors. The most efficient approach is to use an adaptive approach whereby factors such as the time interval between tasks is increased or decreased as the test-taker progresses through the test. The bottom left corner of Figure 4 outlines how the adaptive approach might be implemented.

Table 6.
Environmental Variables related to MT Intensity,
Individual Difference Variables, and MTAT Features

INTENSITY		
Environmental Variable	**Individual Difference Variable**	**Possible MTAT Features**
Rapid vs. relaxed pacing	♦ perceptual speed ♦ tolerance of stress	♦ increase or decrease timing interval between tasks
Consistent vs. erratic switching	♦ Type A Behavior Pattern	♦ vary the pacing of tasks/objects
Task duration	♦ working memory	♦ some task should be quick; some should take time
Interruption frequency	♦ inhibition ♦ working memory	♦ increase or decrease number of external interruptions

As outlined, the proposed MTAT assessment tool will incorporate two of the major dimensions featured in our model of MT environments: type of MT and intensity of MT. It will not, however, address the third dimension noted in the model, severity of consequences. It is not realistic, in a brief, abstract, performance-based test, to assess how severity of consequences and risk-taking preferences affect MT performance. There would be no way to realistically create an environment where failure to correctly perform a task would have consequences severe enough to potentially affect MT performance. However, this is not a major shortcoming of the assessment tool. There are other well-established assessments, such as personality inventories, that the employer likely already has access to that would more directly assess that individual difference variable if necessary.

Assessment Reports

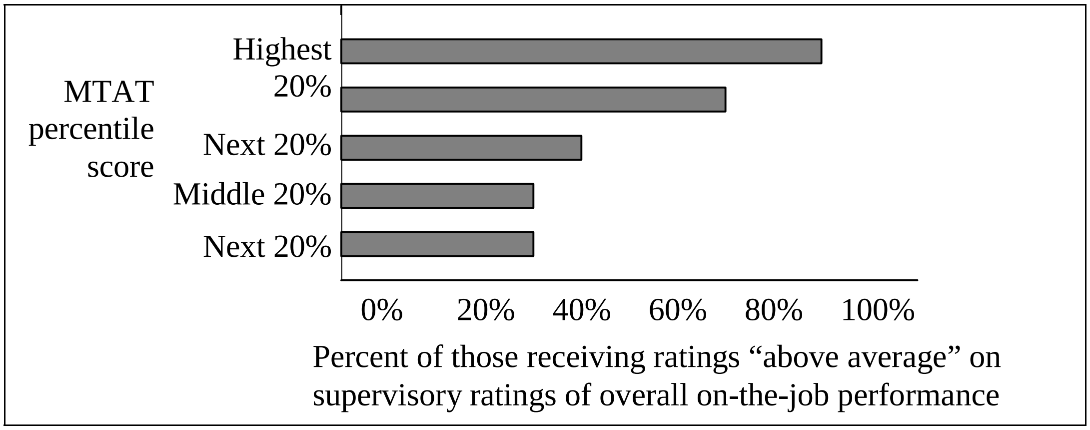
A most important function of the MTAS would be to provide information to organizations about job candidates. Therefore, the MTAS also includes a reporting function that will produce a variety of useful output reports that describe the performance of an individual who has taken a MTAS test(s). After an individual completes the assessment procedure, the test administrator would then be provided with a profile of the individual's MT ability and how it relates to others who have taken the test. An individual's profile package would include the individual's raw scores for each type of test (MTAT-DM, MTAT-TFM, MTAT-IM, or all three) at each level of intensity. It would also provide a percentile ranking score to show how the individual compares to others who have taken the test. Accompanying the individual's data would be an expectancy chart, which will illustrate the relationship between a particular MTAT score and actual workplace performance. Both the percentile rank and the expectancy charts will be created using data obtained from the validation and reliability studies.

For example, an individual who took the MTAT-DM might have a profile that looks like the following chart.

Test: MTAT-DM	Raw Score	Percentile Rank
High Intensity Level	66	85
Moderate Intensity Level	83	90
Low Intensity Level	91	95

Table 7 shows a hypothetical expectancy chart that could be included in the MTAS. The hypothetical expectancy chart shows that among those people who took the MTAT-DM and are employed in a particular job, 95% of the people who scored in the top 20% on the MTAT-DM high intensity measure were rated "above average" on a separate performance criterion such as supervisory ratings of on-the-job performance. Given that the MTAS is intended to be applicable for a wide variety of jobs, it would not be possible to create a cut-off score for the selection of candidates for each potential job. However, it would be possible for test administrators in a particular field to use the expectancy charts, for example, to establish their own cut-off scores, if they so choose, such as selecting a percentile score where 95% of those who score at this level would be expected to qualify for the job after experience and training.

Table 7.
A Hypothetical Expectancy Chart.



Conclusions

The flexibility of the MTAS allows it to be used both as a selection tool and as a placement tool for prospective job candidates. A job administrator who is looking for candidates who can function well and handle the multi-tasking demands of a particular workplace environment, for example, would first complete the ENVAT survey in order to determine which version of the MTAT is most appropriate to administer to applicants. After administering the test, they would then get a report on the applicants’ scores at the various levels of MT intensity, as well as information relating the scores to statistical data on how the scores are associated with predicted performance in that particular environment. This information might then be used as one of the tools to assess the candidate’s fit for the position. Likewise, a job placement counselor might administer all three versions of the MTAT to a job seeker, then use information provided in the test manual to provide guidance about which workplace environments the job seeker would be best suited for. For example, if someone scored poorly on the high-intensity scale of the task flow management version of MTAT, then that person might take that into consideration when applying for jobs that require the ability to manage several ongoing tasks.

The goal of the Phase I research was to determine whether a valid, reliable, and practical assessment tool could be developed that predicts MT performance in a wide variety of MT environments. As the measurement approach outlined above indicates, the MTAS, with its flexible ability to provide tailored assessments of particular MT environments and to deliver tests that tap the demands required by those environments, will capably serve that function.

TEST PURPOSE, SCOPE AND FRAMEWORK

Construction of the MTAS will be guided by the current testing standards set forth by the American Educational Research Association (AERA), American Psychological Association (APA), and the National Council on Measurement in Education (NCME) (1999). The first phase of test development focuses on establishing clear definitions of the proposed test’s purpose and scope. A framework for the test is developed that extends the purpose of the test to describe the construct to be measured. The framework delineates aspects of the construct that are targeted by the test. What follows documents the intended purpose, scope, and framework for the MTAS.

Standards (AERA, APA, & NCME, 1999) that are relevant to the points made in this section are given in parentheses.

Purpose

The MTAS will serve a scientific measurement purpose that can be practically used to address applied needs in MT environments. Broadly stated, the purpose of the test will be to measure individual differences, within normal populations, in multi-tasking ability, tailored to different types of MT environments that vary on key dimensions. The MTAS will also assess the level of intensity of MT that an individual can capably handle. In so doing, the test can be used to identify those individuals who are likely to perform well in different kinds of environments or jobs that require varying levels of MT ability. The test will incorporate a scoring system that predicts measures of asymptotic performance in real-world MT environments, as well as measures of time required to reach asymptotic levels. Hence, it will be both a test of ultimate performance and a test of skill acquisition. (Standard 3.2)

MT ability is a psychological construct that has received increasing attention in the basic and applied literature (e.g., Burgess, 2000; Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Joslyn & Hunt, 1998; Meyer & Kieras, 1997; Proctor, Wang, & Pick, 1998; Yee, Hunt, and Pellegrino, 1991) (Standard 3.1). Simply stated, the MT construct is the ability to concurrently perform or interleave multiple tasks. MT ability is thought to place heavy demands on several executive control functions, which many theoretical accounts include as part of working memory (Burgess, 2000; Burgess, Veitch, de Lacy Costello, & Shallice, 2000). Despite its probable overlap with the working memory construct, current findings indicate that MT ability is a distinct individual difference variable (Joslyn & Hunt, 1998). Current findings also indicate that it has little to no relationship to other constructs such as processing speed and fluid intelligence (Joslyn & Hunt, 1998). These conclusions, however, warrant further investigation for reasons previously discussed. MT ability also incorporates the ability to prioritize the many tasks that must be performed. A body of research exists that supports the existence of individual differences in the ability to concurrently perform or interleave multiple tasks. Recent research (Joslyn & Hunt, 1998) has succeeded in measuring such differences and predicting performance in real-world environments and jobs that require individuals to use the ability. The test will be based on a recently developed laboratory task of time-pressured decision-making (Joslyn & Hunt, 1998; Fischer & Mautone, 2005; Morrin & Fischer, 2005) that has been shown to be highly predictive of simulated emergency dispatching and ATC job performance. (Standard 1.2, 3.2)

Scope

The test is intended to discriminate differences in MT ability among normal populations of adults. Although a body of research has associated MT ability with dysexecutive syndrome and a variety of other neuropsychological disorders that involve impairment of executive control functions (Burgess, 1998; Burgess, 2000; Burgess, Veitch, De Lacy Costello, & Shallice, 2000; Shallice & Burgess, 1991; Wilson, Evans, Emslie, Alderman, & Burgess, 1998), the test is not intended as an instrument to diagnose or otherwise measure such disabilities. The test is intended for adult populations who work in real-world MT environments, and should not be used to discriminate differences among children or aged populations. The test is also intended to have limited generalizability with respect to work environments. It is intended to predict relevant measures of performance in MT environments, but not in stressful, fast paced, nor time-limited environments; however similar these environments may be to MT jobs. (Standard 1.2, 3.2)

Framework

The present research provides a logical framework for understanding MT ability and the proposed MT ability test (Standard 3.1). Standards recognize that this framework may change as test development proceeds through the interplay between construct development and test development (AERA, APA, NCME, 1999). However, current analysis supports basing the MT ability test on the cognitive requirements commonly found in real-world MT jobs *and* the cognitive requirements that different MT environments place on workers. Hence, the MT ability test will incorporate cognitive operations that current analysis shows are critical to successful MT performance. The cognitive operations that appear to be critical are short-term memory rehearsal and storage, working memory updating, prospective memory, divided attention, selective attention, mental set switching, long-term memory retrieval, and prioritization.

Analysis of the MTAT reveals that its current version incorporates and requires participants to employ a set of cognitive operations that are a good match to the operations required by MT environments. Short-term, prospective and working memory operations are integral to the MTAT. Executive control functions such as mental set switching, selective attention, divided attention, and rehearsal for STM are also required by MTAT.

The ability to effectively prioritize multiple tasks appears to be a critical function that workers must perform in MT environments. While the ability to effectively prioritize multiple tasks in the real world is what makes or breaks a worker, we currently do not know if MTAT can be performed relatively successfully without this skill. However, it may be possible to increase the degree to which MTAT measures the ability to prioritize tasks by modifying MTAT's structure, scoring system, or rules. The importance of prioritization to real-world performance in MT jobs warrants investigation of modifications to MTAT to better represent the ability to effectively perform this operation.

PHASE II TECHNICAL OBJECTIVES AND APPROACH

The contributions of the Phase I research noted above lay the groundwork for further development of a multi-tasking assessment system that assesses various MT environments, then provides the most appropriate test to predict individuals' aptitude for performing well in a particular MT environment. This section of the report describes the technical objectives of future research.

The proposed Phase II research is designed to support development of a **M**ulti-**t**asking **A**ssessment **S**ystem (MTAS). The concept of a system that both assesses candidate MT work environments and provides a set of validated tests tailored to predict performance in various MT environments is truly innovative. Hence, the proposed research and development effort is not without risk. Successful development of the MTAS depends on our ability to create a reliable assessment instrument that discriminates MT environments on key variables. It also depends on the ability to identify those key environmental variables most important to individual differences that determine performance in different MT environments. The present research created assessment and model products that meet these requirements. However, those products must be validated to ensure that the MTAS created in future research can be trusted to deliver clear and accurate evaluations of environments and individuals.

The Phase II research constitutes a highly efficient strategy to bring the MTAS to fruition. We consider its objectives to be the necessary groundwork that must underlie the design and development of the MTAS. The research is designed around four technical objectives. The **first** technical objective of the project is to perform the research necessary to develop a reliable assessment instrument that evaluates candidate MT environments. We will use the assessment instrument developed in the Phase I research as a starting point, but will conduct the necessary development and investigation to refine it for use on the Internet. The **second** technical objective is to evaluate, validate, and refine the model of MT environments developed in the Phase I research. To meet this objective, we will conduct a wide scale evaluation of environments using the newly developed assessment instrument created when the first technical objective is met. The **third** technical objective is to develop the structure of the MTAS and all testing and assessment components. Realization of the objective will be a prototype MTAS that is ready for validation. The **final** and **fourth** technical objective is to validate the MTAS as rigorously as possible within the constraints of a Phase II, two-year effort. Three validation studies are proposed that target the most important issues concerning the validity of the MTAS. We consider the proposed research to be a minimum effort to make the MTAS a reality. Because the proposed research both advances the science of MT and addresses real practical concerns, we anticipate that basic and applied researchers will be motivated to conduct additional research once our work is published. Therefore, it is likely that the proposed Phase II work will have significant effects on future knowledge and practice.

The work plan has been designed to achieve the first three technical objective in the first year of the Phase II research. The fourth technical objective will be met by conducting multiple validation studies in the second year of the project.

OVERVIEW OF PHASE II WORK PLAN

Development of a validated Multi-Tasking Assessment System (MTAS) is the main driver to the proposed work plan. Figure 5 depicts the progression of the five major tasks we propose to accomplish in the project, and the associated deliverables. The plan recognizes and addresses the need to base development of the system on a sound body of empirical research and tested theory. Capitalizing on a successful Phase I, we will begin by testing and refining the assessment instrument that was used to analyze various multi-tasking environments.

In **Task 1**, an assessment tool will be developed that will be web-based and self-administering. The purpose of the tool will be to assist new users of the MTAS in defining their particular MT environment. Based on users' responses, the tool will (1) analyze and classify the environment along key dimensions, (2) provide a synopsis of the environment to the user, and (3) guide the users to the appropriate tests for their environment, which may be administered for selection or placement purposes.

In **Task 2**, research will be performed that is necessary to support development of the MTAS. The purpose of this research is twofold. First, it will serve to validate critical theoretical propositions made by the nascent model of MT environments developed in the Phase I research. Second, the research will serve as a testing ground for the newly developed assessment tool, created in Task 1. Based on the studies' findings, the model of MT environments and the assessment tool will be revised as necessary. These refined elements will then be used to adjust design of the MTAS.

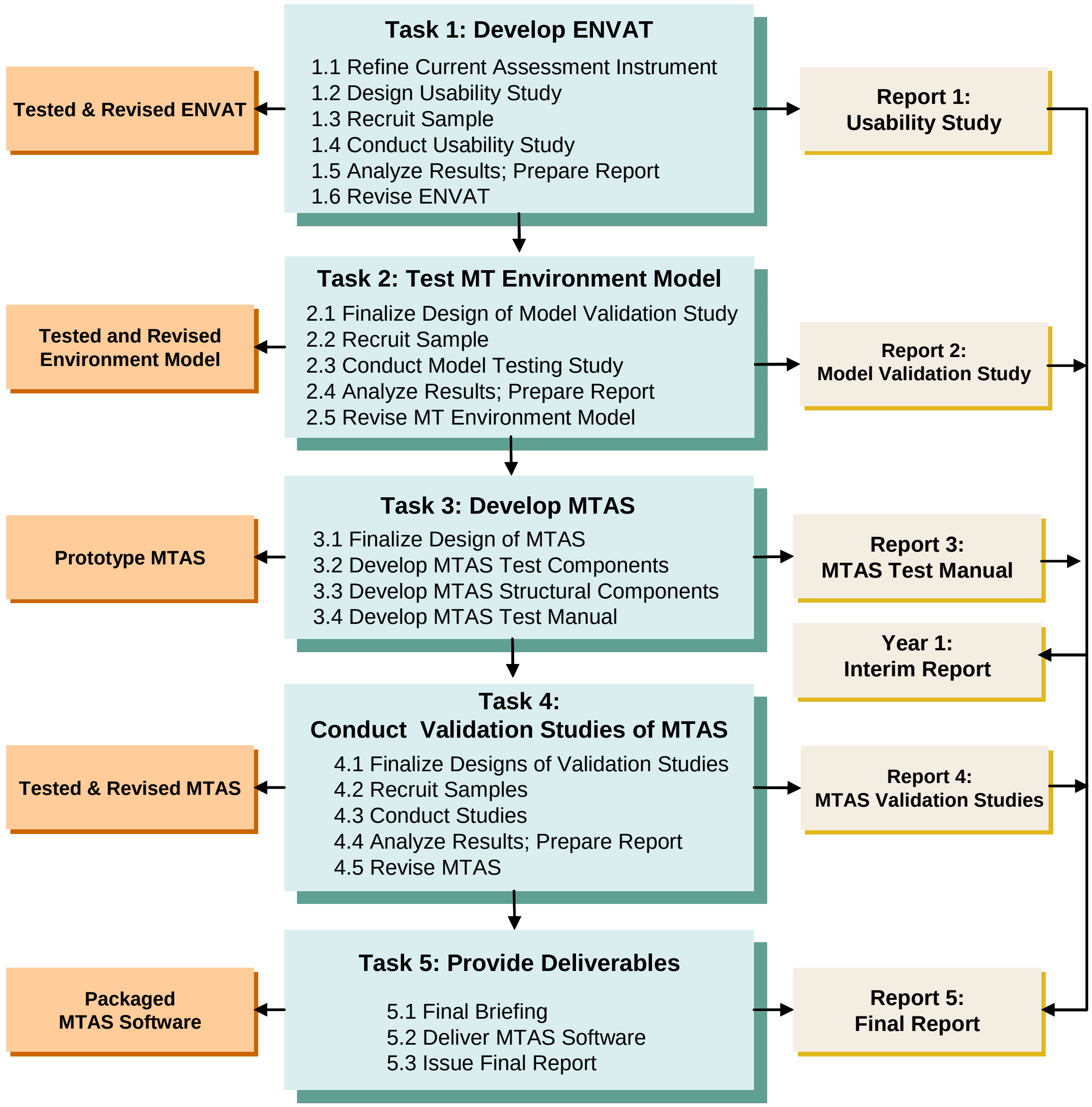


Figure 5. Progression of tasks to complete Phase II and deliverables.

The Task 2 products will be used to guide development of a set of tests, to be created in **Task 3.** The tests constitute key components of the MTAS designed to evaluate and predict individual performance in a variety of MT environments that vary in intensity and kind, according to the model. Structural components of the MTAS will also be developed in Task 3, such as user interfaces, algorithms that dictate sequencing of tests, and linkages between user input and reports. Finally, a test manual will be developed in Task 3 that provides requisite information to the test administrator according to current testing standards [American Educational Research Association (AERA), American Psychological Association (APA), and the National Council on Measurement in Education (NCME), 1999].

Once the tests have been completed, validation studies of the MTAS will be conducted **(Task 4)**. The validation studies will serve multiple purposes. For example, a study will be conducted to determine whether the MTAS differentially predicts performance in different types of MT environments, as designed. The validation studies will also address the following questions. Does it make sense to vary the intensity of the testing instruments so as to predict performance in low and high intensity MT environments? Does it make sense to include component tests that make varying cognitive and performance demands on the test taker, analogous to environmental variations? Do the tests predict the time it takes to learn the job, initial performance, or ultimate asymptotic performance? The project will conclude with a final briefing, packaging and delivery of the testing software and documentation, and a final report **(Task 5)**.

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Army MT Study
SMEs -- Phone Interview Questions

1) GENERAL QUESTIONS:

1a) Which MOS's are you responsible for?

1b) Just so we are on the same page, what do you consider to be multitasking?

- need to emphasize tasks done simultaneously or nearly overlapping, urgency, switching back and forth

1c) On a scale of 1-10 with 1 being very little multitasking and 10 being a high degree of MT, how would you rate this MOS?

1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

low degree high degree

2) NUMBER AND TYPES OF TASKS

2a) What specific types of tasks do they do?

For example: a Civilian Police Emergency Dispatcher must:

- decide which police units to send to an incident
- contact police units to tell them where to go
- monitor incoming messages on computer screen
- report information back to appropriate police unit
- monitor auditory messages
- look up information in a database
- log information
- check on status of police units
- etc.

❑ resource allocation ❑ monitor information ❑ look up information
❑ log information ❑ give directions to others ❑ check on status
❑ interpret data? ❑ prepare reports

2b) Think of an occasion where the Soldier is engaging in a high level of MT. How many tasks are they performing at any given period of time?

2c) Is that level fairly typical? How often do they engage in MTing? (frequently, occasionally, rarely)

2d) Are the flow of tasks fairly steady or are there periods of low MT punctuated by periods of intense MT?

2f) Does the nature of the tasks, the degree of MT change much as move from skill 1, to skill 2 and 3?

3) SOURCES OF INCOMING INFORMATION

For example: Displays, instruments, communication devices such as radar screens, computer screens, wind velocity readings, visual scanning of the tarmac, GPS, radio transmissions, face-to-face communication with other people, etc. If it's a computer screen – then how many separate sources of information does it provide (i.e., is it split into more than one window, each providing information from separate sources?)

3a) For this MOS, how many sources of does the Soldier typically have to interact with? That is, pay attention to and/or check on?

3b) Like what?

3c) How many do they typically have to interact with at the same time?

Normally –

At high peaks –

3d) Do they have to consciously remember to check the information, or are there cues that signal when to check?

4) TASK SWITCHING MEMORY (PROACTIVE, RETROACTIVE, ATTENTION)

4a) How frequently are they interrupted?

1------------------------2------------------------3------------------------4------------------------5

Not very often (15 or so minutes))	somewhat often (every few minutes)	Very Often (every few seconds)

4b) How frequently does a Soldier in this MOS have to switch to another task? That is, stop what they are doing and switch to another task?

1------------------------2------------------------3------------------------4------------------------5

Not very often (15 or so minutes) Relaxed switching Tasks almost done in serial	somewhat often (every few minutes)	Very Often (every few seconds) Rapid Switching Tasks done almost in parallel

4c) Is it more accurate to say that they are doing several tasks at one time or several tasks one at a time?

4d) For this MOS, what primarily determines when a Soldier switches to a new task?

For example: Sometimes the Soldier has no choice about when to switch tasks; the environment (incoming call, alarms, specific orders) signal when to switch. Other times there are no specific environmental cues that and it's entirely up to the Soldier to determine when to switch tasks. In between these two extremes are instances where there are some environmental cues, but it's at the Soldier's discretion about whether to respond to or ignore the cues.

So, how much is when to switch tasks dependent upon the Soldier?

1------------------------2------------------------3------------------------4------------------------5

Not at all (entirely by env.)	Somewhat	Almost Entirely (Soldier determines when)

4e) In some jobs, when you switch back and forth between tasks, you have to be able to remember what you were doing and pick up where you left off. With other jobs, the tasks are more discrete (for example, assigning a police unit to an incident).

Would you say that the tasks are mostly continuous (that is, you have to remember to pick up where you left off; reorient yourself to the task) or more discrete (when you resume the task, you don't really need to remember where you left off).

On a scale of 1-5, how continuous is the task?

1------------------------2------------------------3------------------------4------------------------5

Not continuous (discrete)	Very continuous

4f) How dependent are the tasks on one another?

For example: Do you need to take what you are doing in one task and use it to perform another task? For example, interpreting radar data, then using that information to give instructions to pilots would mean that the data interpretation and the communication tasks are interdependent. On the other hand, two tasks such as typing, then answering the phone would be independent because communicating on the phone does not depend on what you were typing. They are two separate tasks.

1------------------------2------------------------3------------------------4------------------------5

Not at all (Tasks are completely independent)	Tasks are somewhat interdependent	Tasks are very interdependent

5) PRIORITIZATION OF THE TASKS INVOLVED IN THIS MOS:

For example: If a job has task prioritization, it means that there are primary tasks that require more attention or immediate attention, and there are secondary tasks that don't require as much attention as the primary task – or can be postponed in order to perform the primary task. If a job has little or no prioritization, then most tasks are equally important and, at any given time, and if two or more tasks need to be done it usually doesn't matter which one is performed first.

5a) Do the different tasks have different priorities? That is, do some tasks take priority over another?

To what degree is there task prioritization?

1------------------------2------------------------3------------------------4------------------------5

not much	some	a great deal
(most have equal priorities)		(very different priorities)

5b) Are the task priorities clearly pre-defined?

For example: Are there explicit rules and procedures about which task takes priority, or is it sometimes ambiguous and depends on the situation? For example, for a dispatcher, sending out units is top priority, logging info is secondary; for a manager, sometimes top priority is

How explicit is the task prioritization?

1------------------------2------------------------3------------------------4------------------------5

Not very	Task Priorities	Very
(priorities rarely explicit)	somewhat pre-defined	(clearly pre-defined)

(Follow-up: → *So, if someone weren't very skilled at prioritization, what impact would that have?)*

5c) How stable is the prioritization? Is it fairly stable or do the priorities vary depending on the situation?

For example: If prioritization is very stable, it would mean that one task is always first priority, others are always second priority. Somewhat stable would mean that occasionally the secondary task will take priority. Rarely stable means that while there are clearly some tasks that need to take precedence over others, determining which task is most important at any given time requires constant re-evaluation and assessment.

1------------------------2------------------------3------------------------4------------------------5

Task Priorities Very stable	Task Priorities somewhat stable	Task Priorities rarely stable

5d) Who primarily decides what the prioritization is? (Soldier, Supervisor, Procedures)

6) LEVEL OF DECISION MAKING

For most of the tasks, what level of decision-making is required?

<u>For example:</u> For routine or automatic decision-making, there are probably well-established rules and procedures about what to when faced with a particular situation. When X happens, do Y. On the other hand, when deliberate or conscious decision-making is required, there may not be prescribed responses, or there may be several options about what to do and a decision has to be made about which is most appropriate.

6a) How routine are the decisions?

1------------------------2------------------------3------------------------4------------------------5

Not very routine (conscious/deliberate) — Very routine (almost automatic)

6b) Along the same lines, how much autonomy does the person have in making decisions?

<u>For example:</u> Do most decisions involve following established procedures, or do they involve coming up with potentially novel solutions or selecting among multiple solutions?

1------------------------2------------------------3------------------------4------------------------5

Not much autonomy (mostly prescribed responses) — A great deal of autonomy (Novel/multiple potential solutions)

6c) How rapidly do they have to make decisions? Do they usually have to decide quickly or do they have time to consider and decide?

1------------------------2------------------------3------------------------4------------------------5

Not very rapidly (take time to deliberate)	Somewhat rapidly	Very rapidly (No time to deliberate)

7) DEGREE OF TASK URGENCY

7a) Do the tasks need to be started immediately, or could they be temporarily put off?

How urgent are most of the tasks?

1------------------------2------------------------3------------------------4------------------------5

Not very urgent (can wait a few hours)	Somewhat urgent (can wait a few minutes)	Very urgent (need immediate attention)

7b) How rushed is the task? How quickly do they have to work/react?

1------------------------2------------------------3------------------------4------------------------5

Not rushed Can take their time	Very Rushed Must work very quickly

7c) What is the typical speed vs. accuracy tradeoff?

For example: Is the main focus on getting things done quickly or reacting quickly to stimuli? Or is it on accuracy and taking time? Is it better to be fast and sometimes wrong (e.g., have some false alarms) or is it better to take more time and be accurate?

How important is speed?

1------------------------2------------------------3------------------------4------------------------5

Very	Not very

7d) What makes the task urgent?

For example:

- ❑ Time schedule that needs to be adhered to
- ❑ People depend on it
- ❑ May forget about it
- ❑ Need to act now or opportunity is lost
- ❑ Need to act now, or there could be serious consequences

8) STRESS

8a) What are the consequences of failure to successfully perform the task?

For example: loss of life, money, time, inexpensive material resources, expensive material resources. Danger to self or others, personal or professional embarrassment; no loss (if no one finds out), no loss (even if someone finds out), etc. Someone else can do it, you can start over.

Please List:

9) GENERAL QUESTION – PART II:

9a) Besides their ASVAB scores, what characteristics does a person need to have in order to do well in that MOS?

(ex: focused, problem-solving, openness to new experiences, situational awareness, not easily distracted, quick, organized, good memory, need for achievement etc)

Follow-ups:

9b) What distinguishes a top performer from a mediocre performer? (Besides ASVAB and attitude)?

9c) *Can you think of a case where someone seemed like he or she should do well, but had trouble performing the MOS? Why?*

9d) *Do you think there is something that distinguishes this MT environment from other MT environments? (That someone who does well in another MT environment would also do well here?)*

9e) *Are there other jobs that are very similar to this one, but that you would consider to require either more or less MT ability?*

Is there any thing else you would like to add?

Thank you very much for helping out with this project. If you have any additional questions or comments please let me know. My phone number is 805-966-6157 ext. 13.

Could I have your e-mail address in case I have any brief follow-up questions?

APPENDIX B: SUMMARY OF INTERVIEW RESPONSES

		Task and Information Sources					
MOS	SME's Estimated Level of MT (1= low; 10 = high)	Specific Tasks	# Tasks at a time	Steady or erratic pacing?	Sources of Info	# Sources monitored at a time	Skill Level Differences
13F Fire Support Specialist	9	determining where to drop ammo, maneuver artillery, etc.-- resource allocation; planning, coordinating with others; communicate with personnel (lots of cross training); provides air support, monitors and operate communication equipment, maneuver artillery; send/receive messages, getting location information, directing where to go, keeping track of where things are	4-5	mostly high intensity, but some lulls; need to be ready at all times	radio, handhelds, radio digital, glid data, air support info (recon); human intel	all	Skill level 1) monitoring intel coming in from various sources; log it; forward it to others; 2) calling for fire, attack aviation, marking artillery, working laser target; plan, coordinate documents
15Q: Air Traffic Control Operator	6 (for fixed Tower) --	separating aircraft, assigning airspace, deciding which aircrafts get priority; giving ground and taxiing information; relaying weather info to pilot. relaying emergency info to pilots; Tactical AT --setting up an airfield, equipment; mobile tower, mobile ground control approach (radar); logging information, interpret data, monitor info. (NOTE; everyone responsible for all tasks, but often divided -- someone gathers info, gives it to person on mic who relays it to pilot, etc)	about 5-6; talk with pilot, several different people at time, track weather (especially person working mic); relay info, write flight plans, give and take clearances -- but has team support	varies depending on missions	Headset with pilot, land lines to communicate with outside parties (such as getting info from other MOS's about other activities in area that could affect pilot e.g., ordi-nance going off)	5-6 headset, other people, land lines, DBRITE (like radar display), direct visual surveillance,	As progress through skill levels, need more supervisory and technical skills; becomes more like doing one task after another rather than at same time

		Task and Information Sources					
MOS	SME's Estimated Level of MT (1= low; 10 = high)	Specific Tasks	# Tasks at a time	Steady or erratic pacing?	Sources of Info	# Sources monitored at a time	Skill Level Differences
25Q: Mulitchannel Communication Systems Operator	if normal = 2-3. (If problems with links, 7-8)	Establish radio links; set up phone lines; fix lines; occasionally work on more than one mission at a time; log in radio links, troubleshoot problems; occasionally, can do up to 3 lines at a time, switching back and forth between cases. Trouble-shooting = checking for errors, signal strength, check equipment. Periodic (on shift changes) -- perform inventory of sensitive material, general mainte-nance on equipment, run checks; generally monitor links, periodically (every hour/2hours) initiate radio test checks; sometimes has to tell others (distant location) how to fix	if troubleshooting = 4-5 tasks (look up what's wrong, check radio, talk to users; may have two lines at same time; communicate coworkers & supervisors; log information; run through equipment to determine problem	varies -- only intense when there's a problem; if routine maintenance then there's a lot of down time	radio give error message; also see signal strength; person-to-person contact, equipment -- may be for two lines	1 radio set per link, up to 3 links; + phone line; (radio gives error messages) -- all audio (if there's a problem, "phones ring off hook";)	Skill 1 -- follow what supervisor tells you; Skill 2-3 handles more, makes decisions and handle the multiple simultaneously calls; supervisor tells them to run checks
88N Transportation Management Coordinator	7	coordinate transportation movement (air, rail, bus, convoy); make sure they have proper information: manifests, getting dimensions of transported equipment, calculate load; overseeing loading procedures, documenting what equipment is included, doing final inspection, making sure properly packed; document what is going on	3-4 (e.g., inspecting, assisting, monitoring, documenting)	varies	radio, computer (with info on location, type of equipment, etc)	mainly two physical sources-- but computer provides many types of info, and on radio deals with many people; also, need to check and re-check info because things change	Skill 1) workers; Skill 2) supervisors with more responsibilities—over-seeing whole operation, make sure nothing goes wrong; promotion board: look for leader-ship skill, how they perform job, organized, take on responsibility

		Task and Information Sources					
MOS	SME's Estimated Level of MT (1= low; 10 = high)	Specific Tasks	# Tasks at a time	Steady or erratic pacing?	Sources of Info	# Sources monitored at a time	Skill Level Differences
91W: Health Care Specialist	9-10	Varies -- depends on environment. In combat env: working on several cases (e.g. 1 medic assigned to 150 Soldiers), performing triage, assessing level of injuries, determining treatment order and most appropriate method; stabilizing patients then going back and treating them; trauma assessment, establishing IV's, provide medication, prevent shock, attend to symptoms + protect selves, be aware of combat situation. At medical facility/ER they would: monitor vital signs, monitoring patients for symptoms, treating wounds/injuries, securing airways, lab work, paper work.	Is situational: in uncontrolled environment -- can be 6-7	Depends on type of environment they are in: some lulls, but with sustained action, combat env, or training exercise the pacing might maintain intensity; need to be ready at all times	Hospital environment -- several vital sign monitors, lines to sustain treatment. Field environment -- the tools you carry with you, IV's, some small equipment. Some specialties (like dialysis specialists or cardiovascular) have much more monitoring	depends -- several	skill level 1) are trained at level of proficiency, trauma management; but when get to NCO level, have more responsibilities
92G Food Services Operations	7	Progressive Cooking (have several things going at once, staggered timing). At same time: monitoring oven temps, cooking, checking for enough back-up on the line, replenishing; in addition, calculations of ingredients needed, inventory, check quality of products (temps, spoiling, expiration dates, etc); may share responsibilities for different tasks: meats, salad, baking, starches/vegs, short order, office work, rations.	4 -- for example: monitor oven temps; check to see if enough back-up; cooking; go get additional products, if running short; monitoring progress of dishes	steady pacing	monitor temps of various devices (ovens, grills, freezers, etc)	varies	at higher skill levels, need to know more and need to know how to run the whole operation, know rations, make needed alteration rations ordering, checklist, cash, production schedule, inventory; inspection

		Task and Information Sources					
MOS	SME's Estimated Level of MT (1= low; 10 = high)	Specific Tasks	# Tasks at a time	Steady or erratic pacing?	Sources of Info	# Sources monitored at a time	Skill Level Differences
98H: Communicat-ions Locator/ Interceptor	1-2	Morse code collector; copying Morse code; translating to English (Mainly doing one task); like monitoring CB radio -- then locked on task in listening and typing at same time (other MOS interprets what is useful, where it should go)	2 (listening and typing)	long periods of no tasks, then very focused.	one communication line (Morse code)	monitoring mulit-channels, but computer stops when signal reached. On battle-field may have to manually turn dials	more supervisory duties (in charge of 4 people; higher up supervisor 10)
98J: Electronic Intelligence Interceptor/ Analyst	7-8	collect non-communications signals over 5 different systems of ELINT (electronic equipment); receiving data, simultaneously interpreting & cleaning data, preparing reports, frequent briefings; PLUS -- they choose which part of the data to focus on. They also check to see equipment is operating correctly	2-3 (e.g., receive, clean, identify)	packed for hours + downtime but mainly know schedule ahead of time; data stream is constant	four main sources of incoming infor-mation + other sources checked; maps, running lines -- like EEG, text (and audio -- some recognize visual signals based on audio codes)	4 screens -- may be 4 on one screen or divide among 4 screens	supervisor responsible for long-term analysis (update data for final report; reviewing it), taking our intelligence and fusing it with other units' intelligence

	Task Switching					Task Prioritization			
MOS	frequency of interruptions	Frequency of task switching	Who/What initiates switch?	Tasks Continuous or Discrete?	Task Dependency	Degree of Prioritization	Explicitness of prioritization	Who decides prioritization?	Stability of Prioritization
13F Fire Support Specialist	every few seconds	very frequently: every few seconds	depends on skill level; leadership determines priority, but there is some autonomy	Very continuous; need to remember where left off (e.g. working glid, get under fire, need to defend position, then go back to glid)	Very inter-dependent	definitely tasks have prioritization; once finish high priority tasks, reeval-uate &move to other tasks	ambiguous; depends on situation	ground commander; senior leader, but some leeway	
15Q: Air Traffic Control Operator	not much -- primary responsibility is to keep focus on current mission; other people would handle interruptions	have to often switch between talking to different pilots or "cases" -- as much as every 30 seconds (depends on how heavy traffic is);	mainly switched tasks based on env. cues sometimes have schedule about when to call; sometimes someone contacts them	high memory load: frequently have to pick up where left off; remember details of the "cases"	depends on task -- cases not very interdepend ent, but some tasks are (can't do X before Y)	yes -- in terms of which tasks to perform and in terms of which "cases" to handle first	clearly defined: 1st priority is to separate aircraft -- anything else is secondary	by procedures; In terms of "cases" -- depends on things like aircraft speed, etc. also learned	very stable
25Q: Mulitchannel Communication Systems Operator	not often, but may get priority 1 call when working on priority 2	not too often; have time to work on some-thing for 15 minutes then go on to next task - - except when troubleshooting multiple cases (which doesn't happen often)	someone will call -- supervisor will tell them when to switch; supervisor who gets goals from -- things do change	keep log so they know where they left off	dependent -- gather info then use it to solve the problem	yes -- radios are labeled by which case takes priority; but tasks are mostly equal priority	explicit (rules or supervisor dictates)	rules and procedures establish priority (this type of line is priority 1, etc)	stable -- but orders can change
88N Transportation Management Coordinator	always interrupted (mainly by leadership)	depends: mostly every 15-30 minutes; (referring to cases?)	depends: sometimes Soldier, sometimes environment	Very continuous: need to remember where you left off	need to follow proce-dures so every-thing falls in line; very inter-dependent	mostly	depends on situation: rules are set, but need to prioritize in some circumstances	supervisor	somewhat stable

	Task Switching					Task Prioritization			
MOS	frequency of interruptions	Frequency of task switching	Who/What initiates switch?	Tasks Continuous or Discrete?	Task Dependency	Degree of Prioritization	Explicitness of prioritization	Who decides prioritization?	Stability of Prioritization
91W: Health Care Specialist	frequent interruptions -- depends on whether field or hos-pital environ-ment People often inter-rupt & ask you to do something else; also if new patient arrives	depends in a field environment could be every few seconds; hospital, can be more sustained	A lot of decision-making left to Soldier (e.g. when to leave patients, triaging, etc.) Doctors will give orders (check every 15 mins) or alarm might go off; others (like IV's) Soldier needs to remember	mostly continuous; (also: in field situation, don't always have time to log what's been done so need to remember where to pick up)	often need to re-check (e.g. check airway, then interrupted, then need to reassess to make sure no changes) Also --remembering how much medicine given, etc.	yes -- definitely	generally there are rules about what takes priority (e.g. airway, breathing, cardio), but a lot depends on individual situation and how patient is responding	there are a lot of standing procedures, but some leeway (also see comments re: training prioritization)	established, but depends on situation (how patient responds, etc)
92G Food Services Operations	once every 5-10 minutes or so	About 3? every few minutes (may have to switch global tasks as needed)	leaders usually tell them; some self-switching	More continuous (4-5)	mostly interdependent	moderate?	rules and procedures, but sometimes depends on situation	Office writes production schedule, shift leader can modify; subordinates defer to leader	mostly stable
98H: Communic ations Locator/ Interceptor	supervisors interrupted every 5 mins or so; worker on floor is never inter-rupted in middle of copying	once on a task, don't switch; supervisors do have to resume tasks if they were interrupted	equipment signals when to start copying (supervisor will switch when subordinates ask questions)	continuous	mainly one task	clear top priority	explicit	established procedures	stable
98J: Electronic Intelligence Interceptor/ Analyst	infrequent (every 20 mins or so) because isolated; other operators handle new tasks	is sequential (scheduled), but if something happens, they'll need to switch to more urgent task	the schedule is pre-established or decided at beginning of shift; if back-to-back missions; when mission comes in, Soldier in charge reassesses	continuous	mostly dependent	Prioritization -- e.g. getting data coming through; secondary - - checking the system	sometime have a lot of leeway (which part to analyze); if short-term, then less leeway	globally, the schedule establishes it, but in terms of which task to do within a larger project, is up to Soldier	moderate

	Decision Making			Urgency				
MOS	How Routine is the Decision-making?	How Much Autonomy is there in Decision-making?	Rapidness of Decision making	Task Initiation Urgency (can't delay)	Task Performance Urgency (task is carried out quickly)	speed-accuracy tradeoff	Why urgent?	Consequences of failure
13F Fire Support Specialist	must be able to think on one's feet, but also have practiced responses so they are automatic	Under Maneuver commander's discretion; in real war situations -- need to use your knowledge and skills to think on their feet; need to memorize procedures; use common sense	varies	very high sense of urgency	depends	accuracy for most		loss of life
15Q: Air Traffic Control Operator	after initial learning period, most decisions become automatic	Most are routine, but do need to think ahead about what might happen, if something unexpected occurred; do need to be quick on your feet,	depends -- sometimes (esp emergency) have to decide quickly; other times, you have more time	primary tasks can't be put off; secondary can wait a few minutes	initially when set up airfield, it's rushed; then could possibly take time but depends on situation	need to be accurate; during set-up need to be quick, but accuracy key (lives at stake)		people's lives at stake
25Q: Mulitchannel Communication Systems Operator	when new, need to stop and think, but when experienced it all comes with instinct, do it without really thinking; repetitive (those who catch on, are motivated -- can take them 6 mos to be experienced; if not, then up to 3 years)	routine	quickly	some very urgent	supposed to be rushed, but some take their time	accuracy more important		counseling, retraining; if don't do it correctly could suffer injury (high voltage); if break equipment will lose $ and rank; if lines down can interfere with military ops, but usually there's back-up

	Decision Making			Task Urgency				
MOS	How Routine is the Decision-making?	How Much Autonomy is there in Decision-making?	Rapidness of Decision making	Task Initiation Urgency (can't delay)	Task Performance Urgency (task is carried out quickly)	speed-accuracy tradeoff	Why urgent?	Consequences of failure
88N Transportation Management Coordinator	Somewhat routine (e.g. if had planned to go by rail, but can't, then need to decide what to do -- regulations will establish that) have regulations, follow same procedures, but some deviation	some autonomy	usually not very rapid, but depends on situation	need to be done immediately	not rushed, but still aware of urgency	focus on accuracy		professional reprimand; affects units not getting things they need
91W: Health Care Specialist	Many are predefined and often becomes routine. Need to choose best course of action, but with training/experi-ence it becomes automatic. need to make best decision given the circum-stances; hard decisions	do make some individual decisions based on situation, but there are algorithms	need to make timely decisions -- drilled into them	very urgent	need to work quickly	depends on situation: some situations speed is of the essence and worry about accuracy later; other times a mistake could be life and death	patient might die -- often don't have the luxury of taking time to wait and refer	loss of human life; serious injury
92G Food Services Operations	don't have time to think; need to react	not much	quick	sometimes can wait a few minutes	normally rushed; always moving (with progressive cooking)	both speed and accuracy are important	need to follow schedule;	if failure -- will get retrained; loss of materials
98H: Communications Locator/ Interceptor	no real decisions	none -- when message comes in, automatically need to focus on it	na	immediate	rushed	accuracy is important, but need to get as much info as possible; sometimes it's also recorded	messages stream in, can't delay copying them	loss of real world information -- no way to retrieve (possibly life or death info)
98J: Electronic Intelligence Interceptor/ Analyst	established rules and procedures; amount of leeway depends on mission; usually multiple ways to fix the situation	becomes automatic with experience -- need to react or you will fail	depends: some cases you'll lose the data if react slowly	most tasks need to be done at certain time; other tasks more in reac-tion to event	depends	speed important -- can go back and fix mistakes	real-time data coming in	loss of irretrievable information (possibly life or death info)

	Personnel Characteristics			Comments	
MOS	Personnel Characteristics	Additional Skills	Why someone might not do well?	Additional Comments	Summary -- Main Themes
13F Fire Support Specialist	have e common sense; think fast on their feet, intelligent, function in different areas at same time, be resourceful, show initiative when needed; being able to take skills they learned in class and apply them in the field; learn quickly; ; ability to learn new things; to anticipate and plan ahead	leadership traits; technically proficiency; enthusiasm; physical ability	need to keep up with training or will lose it; drop-outs are physically or mentally unable to handle it;	similar MOS with less MT might be 13B (cannoneers) -- they have to do some MT, prepping ammo, etc. but less intense in terms of doing all at once; 13F needs vast amount of knowledge, ability to work in tense environment. Good leaders make it better; some levels (brigade, platoon) have specialists with more specific duties; some self-selection to specific jobs; special forces cross train with this and other MOS's	decision-making, projecting/plannin g ahead; resourcefulness
15Q: Air Traffic Control Operator	Be able to make fast decisions. be decisive -- make decisions at any given moment and make the right ones (or can throw things off); once get into a decision, pretty much committed . Being able to visualize ahead (what could possibly happen) -- projecting different scenarios (what other things out of ordinary could happen and how would I respond to that -- constantly think ahead);		some may be very smart (book smart) but when get in field can't apply it. Problem: can't think quickly on their feet; have hard time visualizing what they are going to do ahead of time; see scenarios think of different ways one can possibly sequence aircraft		a little bit of collecting and monitoring but also put what you collected into action:
25Q: Mulitchannel Communication Systems Operator	common sense, resourceful, quick to analyze/recognize the problem, decisive; focused, organized		lot of "book smart" people don't do well; need to think on the fly; not overanalyze the situation instead of going out and doing it.	more experienced people develop strategies to keep track of the incidents/keep them distinct. Need good STM because supervisors give a lot of orders. Most stressful aspect is sitting and waiting for things to go wrong, best part (to him) is when something goes wrong -- gets to be active, use his brain.	MT mainly seems to involve handling several ongoing tasks at once; remembering to run checks
88N Transportation Management Coordinator	Definitely need to be organized; also have ability to research information/regulations, stay focused		need to like the job; if unsure about things may not do well	most work done in office, coordinating, getting things squared away; have to be able to be doing one thing then remember to do another thing	coordinating information

	Personnel Characteristics			Comments	
MOS	Personnel Characteristics	Additional Skills	Why someone might not do well?	Additional Comments	Summary -- Main Themes
91W: Health Care Specialist	a self-starter; make independent decisions, , make quick, rapid and sound decisions; need to be quick learners -- a lot of information thrown at them at a time; need to focus and pay attention to environment	technical skills	Some may have intellect and ability, but have poor decision-making ability; Even if not good at prioritizing, they learn how to do it -- very structured and regimented (in the military)	High level of responsibility; need to look at specific 91 W roles they play. They train entry Soldiers or conversions to be at level of Emergency Medical Technician; also responsible for combat injuries, varying levels of medical support; trained to work in Medical Treatment Facilities (in ER, inpatient area, hospital wards, health clinics) -- so more versatile than EMTs. Also can get more training	making appropriate decisions, taking initiative
92G Food Services Operations	time management; ability to handle fast-paced environment; for supervisors: knowing Soldiers strengths and weaknesses, ability to give guidance, possessing good leadership skills; when something goes wrong -- being adaptable and able to improvise/replan not panicking, making it happen.	math (ability to convert numbers); read carefully and follow directions;	not trained properly; not given opportunity to master a particular skill	Progressive cooking: need to start and check so don't cook too much. Appears to be a lot of monitoring/guidance at initial skill levels.	keeping several tasks going at once (progressive cooking -- staggered coordination of tasks)
98H: Communications Locator/Interceptor	need to focus/concentrate and not get distracted; can quickly and thoroughly switch from relaxed downtime to intensely focused data interpretation; not get flustered; patience	speed of copying data; audio skills	can't be ADD or ADHD; need to be able to sit with headset on, be patient, for long stretches then be intently focused and tune out all distractions; requires tolerance for stretches of physical inactivity - most of those who don't do well are upset by lack of "action"	sounds like it's not MT, but has some aspects that parallel MT -- ability to quickly switch to a task; ability to direct attention and block out distractions. To have to react at last minute	Low-level MT, but information monitoring & processing

	Personnel Characteristics			Comments	
MOS	Personnel Characteristics	Additional Skills	Why someone might not do well?	Additional Comments	Summary -- Main Themes
98J: Electronic Intelligence Interceptor/Analyst	must be able to make decision on spot -- determine prioritization; trust instincts not the system; research, look up data, know equipment, take initiative to know what is going on around them; like to be active -- to keep up fast pace; tolerate stress, seek out fast-paced environments		Complacency, lack of prioritization, inability to handle stress. Those who are poor at prioritization or who focus on one or two details and ignore others: perfecting a particular piece of data, but didn't go over rest of it; complacency -- if think computers don't make mistakes they process without evaluating it.	Global tasks seem to be "very sequential" -- things are scheduled, planned out ahead of time. When they come on shift, they verify missions, check that everything is okay. Have choice about which tasks to next	Information monitoring and processing

APPENDIX C: DETAILED DESCRIPTIONS OF THREE TYPES OF MT ENVIRONMENTS DESCRIBED BY MODEL

MT Environment Type #1: "Decision Making"

General environment: Provides mostly ill-defined problems and changeable, multiple tasks that require a variety of skills and an extensive specialized knowledge base.

Typical tasks: seeking and gathering information, resource allocation decisions, and making decisions about which actions to take

General Description of Requirements: must efficiently and purposefully gather information to make the best decisions about what actions to take and how to allocate limited resources often on moment-to-moment basis; problems require complex decision making

Typical Military Jobs: 13F Fire Support Specialist; some Health Care Specialists (91W), Company commander.

Typical Civilian Jobs: Some nursing positions (ER), ER physician, Chief fire fighter, some police positions.

Decision-making: Complex, ill-defined problems that have multiple satisfying solutions. Decisions must be quick and some may be automated.

Prioritization: worker is responsible for prioritizing many urgent tasks

Autonomy in Task-switching: High autonomy in switching among tasks

Pacing and Intensity: can be fast paced and intense, or may be moderately paced and less intense; probably variable pacing within each job

Consequences of failure: varies; might be low, medium, or high

Heavy cognitive demands on: fluid intelligence, ability to quickly accumulate and integrate new knowledge

Essential qualities of good worker: ability to prioritize, make quick/appropriate decisions; to learn a wide variety of new knowledge, equipment, and procedures; tolerate stress associated with severe consequences

MT Environment Type #2: "Task Flow Monitoring"

General environment: Fairly well-defined (except when something unusual happens or when somebody makes a mistake); multiple concurrent tasks that require the same kind of skills, limited number of sources of incoming information.

Typical tasks: after initiation of tasks, monitoring progress, checking status, executing prescribed actions

General Description of Requirements: keeping many continuous activities going at once

Typical Military Jobs: 92G: Food Service Operations, some systems operator positions

Typical Civilian Jobs: Dining Services (dorms, cafeterias), some nursing positions (floor nurse in certain hospital departments), factory supervisor, emergency dispatcher

Decision making: fairly routine; not a heavy emphasis on complex decision making

Prioritization: typically prescribed

Autonomy in Task-switching: mainly cued by environment, schedule, supervisor

Pacing and Intensity: can be fast paced and intense, or may be moderately paced and less intense, but mostly steady.

Consequences of failure: varies; might be low, medium, or high

Heavy cognitive demands on: prospective memory, organization skills,

Essential qualities of good worker: time-management skills, ability to coordinate tasks, ability to establish and follow a routine.

MT Environment Type #3: "Monitor Multiple Sources of Information"

General environment: Multiple sources of information that must be integrated.

Typical tasks: Listening to audio messages, monitoring visual displays, interpreting information to make assessments or to extract meaning, possibly integrating sources to deduce or derive trends or classifications

General Description of Requirements: Monitors information from many sources and either integrates or responds to each bit of information. There is less of an emphasis on actions in this environment and more of an emphasis on assessment, integration, and interpretation of multiple information sources.

Typical Military Jobs: 98J: Electronic Intelligence Interceptor/Analyst; 88N: Transportation Management Coordinator

Typical Civilian Jobs: Control room operator in power plant, pilot under certain task conditions, ICU nurse

Decision-making: Fairly and typically routine; not a heavy emphasis on complex decision making, except when something goes wrong.

Prioritization: Does not require prioritization to the same degree as other environments.

Autonomy in Task-switching: Mostly directed by environmental cues (incoming information)

Pacing and Intensity: can be fast paced and intense, or may be moderately paced and less intense; pacing could be either fairly steady or erratic

Consequences of failure: varies; might be low, medium, or high

Heavy demands on: divided or focused attention, interpretation and integration of information

Essential qualities of good worker: good short-term memory, ability to allocate attention effectively – and adapt to the requirements of the situation.